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THE NEW BOURSE OR COMMERCIAL EXCHANGE AT PARIS.

THE NEW BOURSE, PARIS—DESIGNED BY M. BERTEAULT.

THE inauguration of the Commercial Exchange took place on the 14th of September, under the presidence of Mr. Tirard, Minister of Commerce. The exchange, bounded by Viarmes Street, which is circular, is cylindrical. It occupies an area of 28,000 square feet, is 148 feet in height, and is constructed of white stone, in the style of Louis XVI. It consists of a circular hall, 21,000 square feet in area, capable of accommodating 3,000 persons, and the exterior of which will be occupied with offices. This hall is surmounted with a glass dome.

The general aspect of the building is simple and pleasing. Work upon it was begun on January 2, 1888, under the direction of Mr. Blondel, seconded by Mr. Werksin. The work cost $1,400,000.

The new exchange stands upon the site of the palace of Marie de Medici, of which there no longer remains but one column, upon the top of which the superstitious queen was wont to observe the stars. It was constructed for the first time by Philibert Delorme, and, after alteration, was taken in hand by Mr. Blondel. The cupola that replaces Delorme's (which was burned in 1800) was put up by the Creusot works. It occupies the apex of the dome, which is ornamented with paintings outlined upon zinc. These paintings, separated by figures by Mazerolle representing the four cardinal points, are by Luminais, Lucas, Langee, and Clairin,

They celebrate the commerce of the different parts of the world.

The central door, which opens upon Jean Jacques Rousseau Street, is crowned by an entablature which is completed by a fronton by Croisy: The City of Paris surrounded by Commerce and the Industries, and, to the right and left, two pretty children brandishing a caduceus. Two painted modillions in one of the halls give the little known phases of the building's history.

The Commercial Exchange was instituted as far back as 1815. At about this epoch a few merchants decided to meet in order to discuss their interests. They first met at the Stock Exchange, but were soon driven out by the ever-increasing number of speculators. They then organized a society which, under the name of the Commercial Circle of the Louvre, lasted until 1889.

A little while afterward, the complaints made against the sellers of damaged goods or merchandise of bad quality began to multiply. The merchants met and appointed a committee of experts, but the latter was powerless to prevent all the conflicts. A committee on regulations was then instituted, whose arbitration received official sanction and whose decisions were soon always admitted by the tribunals of commerce.

The association then existed, but it needed a home. It wished in the first place to become official. Six professional syndicates were formed, the Circle of the Louvre was organized as a general syndicate, the brokers united, a petition was addressed to the government, and the erection of a commercial exchange was decided upon. The enterprise was confided to Mr. Blondel, who, against a cession of all rights for sixty years, agreed to rebuild the old Grain Halls and to give the building over to the city at the end of the sixty years.

To complete these details, let us add that the exchange will be in operation from 1 to 3.30 o'clock. The hall, the access to which will be public, will be in charge of Mr. Poinier, the president of the Chamber of Commerce.

Various administrations will be installed around this hall. Sales will be made here from samples, and will concern seeds, grain, flour, oil, sugar, and alcohol.

The business handled will be very large, to judge from the registers of the various banking establishments upon which already figure the names of two thousand large merchants. Two hundred banks will have offices in the building, and the employes necessary to conduct them will number nearly two thousand. —*Le Monde Illustre.*

DAYS AND NIGHTS BY THE SEA.*

By Francis H. Herrick.

For one who has spent his life inland, a visit to the sea, and especially to the tropical sea, is an event to date from. The revelation of a new world awaits him. Strange forms innumerable meet him at every turn, and he soon comes to realize that the sea is the great home of life.

The simple outfit of thirty years ago is utterly inadequate for the student of nature of to-day who hopes to add anything of importance to our knowledge of the organic world. He needs not only good microscopes, drawing materials, ample aquaria and dredging apparatus, but a large assortment of chemical reagents, the use of which in the preservation and study of living matter has almost revolutionized the science of biology.

Nearly all marine animals discharge their eggs into the water in vast numbers, and the young which are hatched from them, in most cases, lead an independent swimming life at the surface of the ocean. This locomotor larval period, as it is called, may extend over weeks or months, and is shared by animals which in the adult state have the most diverse habits, such as the coral, the barnacle, and the mussel, which are firmly anchored to some solid support, the starfish and sea urchin, the jellyfish and annelid, the crabs and prawns, the salpas and amphioxus; and also the fishes, the highest type of the marine life which pass their early stages at the surface of the sea. The young of these and of a hundred other forms swarm in the surface water on still evenings, in countless myriads, the most delicate creatures, many of them as transparent as glass, and so small that it requires a microscope to see them. After passing through metamorphoses more wonderful than any described in the tales of Ovid, the remnant of this host which nature allows to live takes on adult characters. The young crab or prawn after having gone by several aliases, and played as many distinct roles, sheds its skin once more, sinks to the bottom, and except in point of size is indistinguishable from an adult. One would hardly have guessed that a larva like that of the mollusk, with its enormous locomotary sails and its delicate fringes of cilia, would ever develop into a sedentary slow-moving gastropod, or that the grotesque microscopic larva, shaped like a painter's easel, would ever turn into a symmetrical starfish with its five horizontal rays.

If one spends a few hours in the Gulf Stream on a calm day or night, he cannot fail to be impressed by that vast stratum of living beings which this great ocean current bears hourly upon its bosom. Once, when off our southern coast, we sailed through a school of medusæ which must have covered many square miles of ocean. They were little brown bells, the size of thimbles, and the indigo water was peppered with them. We encountered them about four o'clock in the afternoon, and for more than an hour their numbers did not sensibly diminish. But at night the dark waters glow with the phosphorescence of those minute and obscure beings whose presence one would not suspect by day unless he had microscopic eyes. Through every mile that the ship plows her way, her bow encounters a steady stream of shooting stars. Every movement in this living water precipitates a shower of sparks, and every spark is due to an organism. There are stars of the first magnitude, like the large medusæ glowing like red hot cannon balls, besides a whole galaxy of lesser lights.

Much of the time of a naturalist at the seaside is spent in the collection and study of these pelagic larvæ and the adult forms which they represent. A calm summer's evening, when not a ripple breaks the mirror of the surface, is best for this purpose. With a companion to take turns at rowing, or to hold the net, we glide off in the darkness to some point where a distinct current sets, or, better still, two currents meet, for in such places pelagic larvæ are most abundant. The apparatus for "surface collecting," as it is called, is simple enough. It consists of a tow net made of bolting cloth or coarsely woven silk, through the meshes of which the microscopic animals cannot pass, and a bucket of sea water. The net is put out and allowed to skim the surface as the boat moves slowly through the water. If the place and time are very favorable the net soon begins to glow, as if made of platinum gauze, heated white hot, and at short intervals it is cautiously raised to the boat, and the sparks are washed off into a bucket of sea water, and the process repeated. After returning to the laboratory, the water containing the evening's catch is carefully examined by each student, who selects and preserves those particular organisms which he happens to be at work upon at the time.

If a tall beaker of this water is dipped from the bucket, and held up to the light, we may behold a most remarkable and fascinating sight. Every drop is teeming with life. The myrmidons of the deep are here. The young of almost every type of marine life has a representative in our glass, but so disguised are many in their undeveloped state that only the specialist may recognize them. They vary in size from half an inch long down to microscopic proportions. Some are adults. There are innumerable larvæ of crustacea, of grotesque shapes, moving with quick jerks; some with the body stuck full of spines, or with a huge straight spear growing out of the forehead; glass-like Ctenophoræ reeling through the water, propelled by encircling bands of iridescent cilia; veliger mollusks floating with sails wide spread; bead-like larvæ of annelids, which swim with rapid rotary movement: the colorless eggs and quaint fish embryos, whose large black eyes and enormous golden yellow yolk sacs attract the eye while their transparent body is hardly visible; the pulsating bells of ghost-like jellyfish, rising and falling as they deliberately contract and expand their disks; the floating Siphonophoræ, transparent as the air and delicate as spun glass. In the turmoil of the moment a thousand strangely beautiful forms pass rapidly before the eye.

The larvæ selected for study are carefully set aside in beakers of sea water, or in watch glasses, and it is sometimes possible to keep them alive for a number of days, and observe their transformations, but usually, unless there is means of providing them with freshly aerated sea water, this is not possible. Some forms are so delicate that one is hardly able to bring them in alive. They die as soon as caught.

Where it can be done, by far the most satisfactory method of studying the development or life history of an animal is to procure the adults and keep them under observation until they deposit their eggs. The development of the ova can then be studied with the closest detail, not only by the superficial view of the growing embryo, but by means of the sectional method which has yielded such valuable results to natural science in the past ten years.

In the case of many animals, such as fishes, "king crabs," oysters, starfish, and sea urchins, where the sexes are separate, the ripe eggs can be obtained and fertilized artificially, and the complex processes by which the highly organized fish or mollusk is slowly built up by changes which start in the germ cells can be witnessed in all their details. Animals differ very widely in this respect, however, and the vitality of the ova is connected in some cases certainly with that of the animals themselves. Starfish or Ophiurans may be sadly mutilated without killing them, and some of the mollusks are notoriously hardy.

A year and a half ago I brought from the West Indies a collection of marine shells, gathered in the water or on the coral rocks on shore. They were done up in a package and sent with other collections to my home in New Hampshire. The next fall, when the bundle was opened, much to my surprise, a number of the univalves (*Tectarius muricatus*) were alive and crawling about. In one of our Eastern colleges, some mollusks brought from the Holy Land were placed in the college collection and duly labeled, when some of them exhibited their vitality by walking off the museum cards.

The "horseshoe," or king crab, which any one who goes to the Atlantic seaboard can usually find on any sand flat, is an animal remarkable not only for its great antiquity, but for its extreme hardiness, which is perhaps one cause of its great age. They are found fossil in the primary rocks, in the Cambrian and Silurian formations, and therefore, excepting the Foraminifera, they are among the oldest animals known. The related trilobite has perished utterly, and a whole army of other forms, but the king crab has existed during all these ages and has altered but little; hence we must infer that their conditions of life have been nearly uniform during this immense period. When the embryology of this animal was being studied at the marine laboratory of the Johns Hopkins University at Beaufort, N. C., a few years ago, an attempt was made to fertilize the eggs artificially. As the ova did not at first show any of the usual signs of development, but began to swell as if undergoing decomposition, they were set aside and forgotten. In about three weeks from this time the dish was examined by chance, when it was seen that the young king crabs were just leaving the shell, notwithstanding the fact that the water in which they had lived was impure, and had nearly evaporated.

The following anecdote, which illustrates what the adult king crab can stand, I heard from Professor Brooks, of the Johns Hopkins University. While he was studying with Louis Agassiz, at Cambridge, Milne-Edwards, the renowned French naturalist, sent to this country for some specimens of the American king crab, on which he was then preparing his well known monograph. The animals as soon as captured were taken to the Cambridge laboratory and thrown under a building, where they remained some weeks, exposed to a low temperature. They were then packed up and sent abroad, and when they reached Paris, some of them were still alive. It is interesting to notice that this animal is not a crab at all, nor indeed a crustacean, as the recent study of its development has most certainly shown. It is more nearly related to the spiders.

The case is very different with the ova of many other animals, for instance, the eggs of prawns, such as the lobster and the shrimp. They are not discharged into the sea and left to take their chances with enemies, but are attached to the body of the animal, which carries them about until they hatch. In most cases they are fastened by fine threads of glue to the swimming legs, and as the constant motion of these appendages is shared by the eggs, the latter are always well aerated. If the ova are removed from the animal, they invariably die.

Some crustacea (like the stomatopods) lay their eggs in masses in burrows in the sand or in coral rocks, and if they are removed and placed in an aquarium they also die. But, if the habits of these animals are studied, it is found that either the male or female is always brooding over the eggs and fanning them with its legs, thus supplying the needed aeration by the currents of water set up. This process of supplying the necessary oxygen is seen in fish-hatching houses, where the eggs are laid upon shallow trays, over which a stream of water is constantly passing.

The eggs of animals like the corals and sea fans can be easily obtained in the breeding season by placing a colony of the polyps, like a piece of living coral, in a glass dish or aquarium. The minute spherical eggs or young will be discharged through the mouths of the polyps and float to the surface, when they can be skimmed off, transferred to other dishes, and their development watched. With the modern appliances and methods of research, the naturalist of to-day can investigate the problems of animal life with far better success than was possible a generation ago. How is the life history of an animal written? How do we trace the numerous links in the chain of events between the one-celled, apparently homogeneous egg to the highly complex animal which produces the egg? To answer this question very briefly, we may conveniently select the shrimp, although we might choose equally well a fish, a sea urchin, or a coral.

It is well known that the eggs of the higher animals, the mammals, are few in number, and that when fertilized they are not discharged, but remain and develop in the body of the parent. Partly for this reason the embryology of the higher forms is much more difficult, but the eggs of the lower animals, like crustacea, corals, and starfishes, are deposited in very great numbers. The number of eggs laid by the edible crab (*Neptunus hastatus*) of the Southern States, for instance, is estimated at 4,500,000. The eggs are not only passed out of the body, but in many cases develop quite independently of the parent. Consequently, a store of food, called *yolk*, is laid up in the egg, as we see in the hen's egg, for the use of the growing embryo.

We start with the fertilized germ cell, the egg, although it should be remembered that there is a long series of events before this is reached. The germinal cell itself is derived from other cells in the tissues of the mother, and the tissues which compose the body are themselves derived from the egg, and this cycle is repeated generation after generation. The male germinal cell, which in fertilization unites with the ovum, has a similar origin, so that the egg from which the animal springs is not as simple a structure as one might suppose, but a microcosm in itself, containing, as it must, the hereditary germs of a long and complex line of ancestors.

As a rule, an egg does not develop unless it unites with another kind of cell, called the male germinal cell. This rule is, however, violated in the case of the parthenogenetic insects, the gall wasps, bees, and moths, and in some crustacea, where the eggs develop without fertilization, and where the males are sometimes wanting.

The egg of the shrimp, like that of the hen or tortoise, consists of a large mass of food yolk surrounding the more essential part of the cell, the nucleus, as it is called, the whole being enveloped by a protective membrane, the shell. Beginning, then, with the single egg cell (which, if fertilized, is, of course, duplex in nature), the animal is slowly developed by the division and differentiation of its products. The nucleus, and sometimes the whole egg with it, divides into two, four, eight, sixteen parts in geometrical ratio. The resulting cells, however, do not separate as in the lowest forms of life, but remain united, and do not long continue alike, but become differentiated. A very complex physiological division of labor is finally established among them, and when the adult condition is reached, the body is a colony of probably many millions of cells, constituting various tissues and organs, all of which work correlatively and harmoniously for the good of the whole. The adult healthy body may thus be compared to an ideal state, where the cells represent individuals or individual minds, all of which have the same faculties, although developed in different degrees. Yet all these subordinate units work together in a wonderful way for the good of a higher unit, the body or state. As the state has its executive and police officers to guard its interests and enforce obedience to its laws, so the body has the nerve cells of the nervous system, which, in health, regulate and co-ordinate the working of all the other organs.

This fundamental conception of living things, known as the cell theory, was announced fifty years ago. It is no longer a theory, but a fact, and from it every problem in biology must proceed.

How, then, is it possible to follow these delicate and intricate processes by which the complex cell state or community, which we call the animal, is developed from the egg? The changes are chiefly internal, while the eggs, which are usually of microscopic size, are frequently opaque, and the protoplasm of living matter of the cells themselves is colorless. Difficulties such as these, however insurmountable they may have been a generation ago, have been completely overcome, and it is now an easy task to divide an egg, which we will say is 1-25 of an inch in diameter, or the size of a pin's head, into a series of 100 sections, each 1-2500 of an inch in thickness. These may then be placed in serial order on a strip of glass, and each of the 100 sections, which can now be studied with high powers of the microscope, is seen to be a picture in color, which plainly tells of the marvelous processes which have been going on unseen in the colorless living protoplasm of the cells.

The eggs of our shrimp are taken at short intervals during several days or weeks, so that the series will represent the whole history of growth from the egg to the young prawn. The ova are then killed and hardened by suitable reagents, and finally preserved in alcohol. They are then stained with certain dyes,

* Part of a lecture delivered in the "University Lecture Concert Course," Jan., 31, 1889. Western Reserve University, Cleveland, Ohio.

like carmine, hæmatoxylon, or osmic acid (which both kills, hardens, and stains protoplasm at the same time). A great step was taken in modern biology (and especially embryology) when it was discovered that protoplasm has such a remarkable affinity for the aniline and vegetable dyes. The colorless and invisible can be made to yield the secret of hidden change in colored pictures. Furthermore, it is probable that certain kinds of protoplasm, or protoplasm in certain stages, combines only with particular dyes.

The stained eggs are then saturated with paraffine and embedded in a block of this substance. The paraffin block is clamped in the holder of a microtome, an instrument for cutting very thin sections, and then, thanks to the property of the paraffine, each section, as soon as cut by the passage of the knife, adheres by its edge to the section following, so that a paraffine ribbon can be cut, a yard long if necessary, in which the embedded egg will now appear in the form of a series of very thin colored sections, arranged in serial order. It is then a simple matter to fix them upon a glass slide, to remove the paraffine, and to seal the whole in a drop of balsam. Thus may we bring out the hidden writing and read the secret manuscript.

We have not the time to follow in any detail the life history of an animal like the shrimp, however interesting it might be, to see how from the simpler the complex arises, how the adult, with its tissues and organs each so remarkable and often complicated in itself, arises from comparatively simple beginnings, and how the individual in its own life history repeats in an abbreviated and modified form the history of the race, but we do well if we realize this wonder of wonders, the development of the higher animal with its marvelous organs, the eye, the heart, and brain, from the egg cell. If the eye or the brain is complicated, what must we say of this unicellular germ, the egg, in which, in large measure certainly, the adult structure must potentially exist?

Some may think that since the young of different animals are subjected to peculiar conditions, to varying climate, food, and the like, their differences in structure may be influenced by their surroundings. But this objection is easily answered, for we can rear the eggs of such diverse forms as the fish, the sea urchin, and the oyster in the same tumbler of water, where the conditions are identical. We are thus brought face to face with the great problem of *heredity*, that is, the law by which all living things tend to resemble the parents from which they sprang, or some ancestor belonging to their immediate race, in spite of variability or adaptation to environment. That the coral polyp reaches a certain stage of development and stops, that the starfish travels by this same road but advances far beyond, the young always coming to resemble the adult; that the higher animals pass still farther along this path; that the child resembles its parents often to a trick of speech or to a shade of mental or moral character, or that sometimes the character of a preceding generation makes its appearance, is one of the most remarkable phenomena which man has observed. Marvelous as it is, it seems not to be inscrutable, and the studies of recent years are lightening its dark passages.

It may be asked, Of what use is the knowledge of the structure and development of animals below man? The chief aim in natural science is to discover relations. The life history of a coral is valuable for the light it throws on the problem of all organic life. The great laws governing all living matter are the same. We can only read the complex through the simple. The lower we pass in the scale of animal and plant life, the simpler the structure, the more nearly are the problems reduced to lowest terms.

The most interesting object in nature is man, and apart from the high claims of pure science, of knowledge for its own merit, our studies naturally come to a focus in man. The history, the welfare, and the destiny of man are questions which interest all civilized people.

Biology or the natural history of living things deals with the phenomena of organic nature, and to man, its central figure, it constantly returns. Morphology, the study of structure, physiology, the study of function, pathology, the study of disease, and medicine, the study of treatment, go hand in hand, and are mutually dependent. We sometimes hear well-meaning though misinformed persons speak of naturalists who spend laborious years of travel and devote their lives to research as if they were bitten with the mania of discovering new species. This is, of course, a great mistake. The history of every science begins with the naming of things, but this day is long past, and, as Agassiz said in one of his cabin lectures when on his way to Brazil in 1865: "This is now almost the lowest kind of scientific work" . . . "The work of the naturalist, in our day, is to explore worlds the existence of which is already known; to investigate, not to discover." . . . "The discovery of a new species, as such, does not change a feature in the science of natural history, any more than the discovery of a new asteroid changes the character of the problems to be investigated by astronomers. It is merely adding to the enumeration of objects. We should rather look for the fundamental relations among animals; the number of species we may find is of importance only so far as they explain the distribution and limitation of different genera and families, their relations to each other and to the world under which they live. Out of such investigations there looms up a deeper question for scientific men, the solution of which is to be the most important result of their work in coming generations. The origin of life is the great question of the day. How did the organic world come to be as it is?"

A generation has passed since these words were uttered, yet how true they still read! Much, indeed, has been accomplished in this period; the horizon of all science has widened. The germ theory of infectious disease has become a science, and is now revolutionizing the practice of medicine and surgery.

Says a well known physician: "Looking into the future in the light of recent discoveries, it does not seem impossible that a time may come when the cause of every infectious disease will be known." . . . "What has been accomplished within the past ten years as regards knowledge of the causes, prevention, and treatment of disease far transcends what would have been regarded a quarter of a century ago as the wildest and most impossible speculation." Embryology has been enriched by the discovery of new means of research. Some of the best work in physiology has been done. Darwin's theory of the origin of species has been tested as a working hypothesis, and been found fruitful in valuable results. The work of the naturalist by its application to the economic industries of the nation can appeal to all classes. The service of the Fish Commission and of the Entomological Bureau annually save the country from great losses, and add to its resources. Our valuable food fishes are artificially raised, and the depleted pond, river or sea coast can be stocked anew. The oyster can now be reared from eggs artificially fertilized, and the young lobster has this last year been safely transported across the continent, and planted on the shores of the wide Pacific.

But the study of nature has another and less serious side, and here I refer to outdoor nature as well as to indoor pursuits. It adds pleasure to life. It gives a zest and object to every walk or ride which one takes in the open air, to every camping and hunting excursion to the woods. It lengthens life, or what is the same thing, our experience, because we see just so much more of this beautiful world. Many people think that science is not only difficult but dry. This is a sad mistake. The scientific treatises which Charles Lamb would class with books that are *not* books may be tedious to the beginner, but the student is not restricted to these or to the musty folios of the past in making his acquaintance with animal and plant life. Technical works are not intended to be read, but, like dictionaries, they are useful to consult.

"Botany," says Sir John Lubbock, "is by many regarded as a dry science. Yet without it one may admire flowers and trees as one may admire a great man or a beautiful woman whom one meets in a crowd; but it is as a stranger. The botanist," or "one with even the slightest knowledge of that delightful science, when he goes out into the woods or into one of those fairy forests which we call fields, finds himself welcomed by a glad company of friends, every one with something interesting to tell."

The faculty of observation, so preternaturally acute in some minds like Aristotle's or Humboldt's or Darwin's, is rudimentary or dormant in a very large part of mankind. Said Emerson: "If men should see the stars but once in a thousand years, how would they wonder and believe!" The cheapness of the pleasure may be fatal to its enjoyment. They see only the mud and soot where the gold and diamond lie. They have eyes, but do not use them, and like Laura Bridgman are cut off from many of the enjoyments of nature. As Lubbock well says, many still "love birds as boys do—that is, they love throwing stones at them; or wonder if they are good to eat, as the Esquimaux asked of the watch; or treat them as certain devout Afreedee villagers are said to have treated a descendant of the prophet—killed him in order to worship at his tomb."

The study of natural history, or biology, if we use the newer term, not only awakens the mind by cultivating the faculty of observation, but widens our enjoyments and enlists our sympathies, giving us a new and human interest in the manifold living beings around us which hold life by the same tenure as ourselves. It also fits in well with those instincts which we seem to have inherited from primitive man, with hunting and fishing, and also with travel, the facilities for which were never greater than in our day, and with short vacations in the country, all of which it enhances in interest, and to all of which it insures success.

THE NEW BOURSE, PARIS—INTERIOR VIEW.

Says T Digby Pigott: "Of all the poor creatures whose fate it was to be strangled or battered to death by Hercules there was only one who made a really good stand-up fight, and at one time seemed to be fairly beating him. He was Antæus, the son of the earth. Every time that he fell and touched his mother—we should say 'ran out to the country'—he came up again with fighting powers renewed. It was not till Hercules found out his secret and held him up, never letting him fall—we should say 'stopped his Saturdays till Mondays out of town'—that he quite broke him down. It is a myth in which the wisdom of the ancients is written for our admonition, in whom the ends of the world have come, the lesson that the best cure for a tired head and irritable nerves is the touch of Mother Nature—to escape from the din of the city, and the everlasting cry of 'extra specials,' and lose one's self if only for a day among the wild creation."

The life and structure of the simplest animal or plant is a marvel, the greatness of which we are utterly incapable to conceive, and one of the plainest teachings of everyday science is that mere *size* is no test of importance. One might suppose that the microscopic cell was too small to be taken into account at all and to spend days and nights in the study of such objects must be a stupid sort of amusement. But an elephant is only an aggregate of these little cells, and the nefarious microbe or floating spore, so small that it takes the highest powers of the best microscopes to clearly discern it, and so light that it floats in myriads on the wings of the viewless air, is also a cell, and unfortunately for man, when breathed into his lungs may be capable of multiplying indefinitely, and producing terrible disease and death. The coral polyp, insignificant enough when contemplated singly, is able to girdle the globe, only give it the time and favorable conditions. The leaven, however small, which is hid in the meal, will in due time leaven the whole lump.

The mountains were not upheaved in a day. The hills have been carried by the touch of the rain drop and the flow of the ice stream and river. The smallest fragment of coral rock, which is among the youngest of modern formations, is but a phase in the endless cycles through which all matter runs. The rain united with the carbonic acid of the earth and air divides the solid rock, and the rivers from the four corners of the earth carry down the molecules of lime in a ceaseless current with the common sea, where, says Dana, "after circulating over thousands of miles and for unknown times, they are brought to light and rendered tangible again by the incessant labors of millions of minute living gelatinous bodies, and by these insignificant organisms the lime is built up again into masses almost rivaling the original in dimensions and importance, but losing in this, its new dress, all traces of its divine origin and divine age." Thus he says, "we may have rocks from the snow-covered summits of the Himalayas, the limestones of the burning plains of India, and the strata of inaccessible China, removed from their respective districts—into the great common receptacle."

Modern science teaches that the small has produced the great, that the earth as we now know it has been fashioned by forces which are in operation to-day. The small indeed may be the most significant, and size in the vocabulary of biology at least may be an unimportant term.—*American Naturalist.*

THE RUSSIAN IZBA, OR LOG HOUSE, AT THE PARIS EXPOSITION.

IN one of the thickets near the Eiffel tower, hidden under the birches and weeping willows, is a little cottage, a veritable Russian *izba*, made of the trunks of firs and covered with thatch, as the illustration shows.

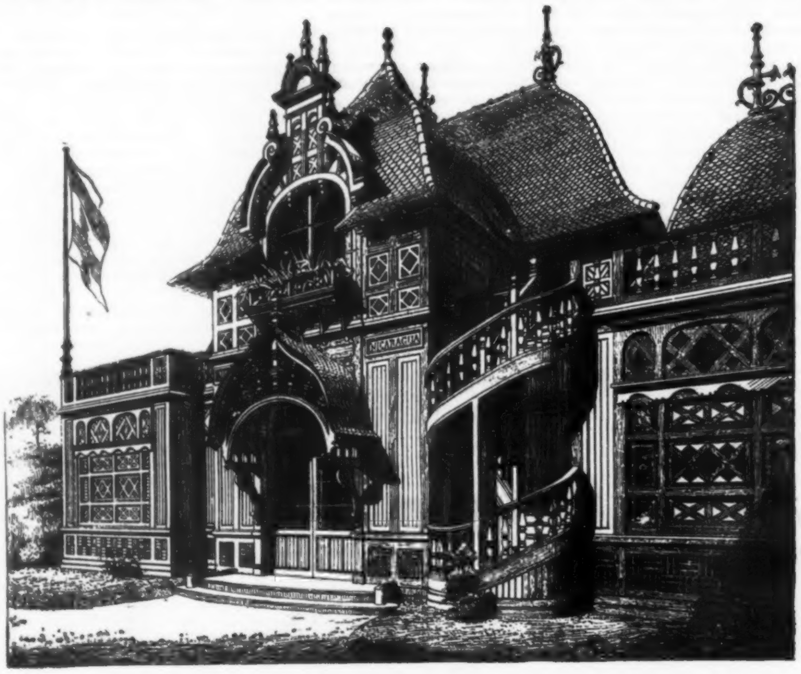
This little rustic structure contains an exposition of small objects carved in wood, made by "moujiks," and representing images of saints, groups, spoons, and knives, all admirably carved. This industry exists in Russia, in the little town of Troitz, sixty versts from Moscow, near the convent of Sainte Serge. The idea of this interesting exposition originated with M. Lution, a Frenchman in Moscow.—*La Semaine des Constructeurs.*

THE RUSSIAN IZBA, OR LOG HOUSE, AT THE PARIS EXPOSITION.

A BOAT 14 feet long, 4 feet wide, and fitted with a propeller driven by a Perret electric motor and storage batteries, has been made by Mr. G. G. Grower, at Ansonia, Conn. The boat runs five miles an hour for eight hours. Fifty cells are used, which are charged from a dynamo.

THE PAVILION OF NICARAGUA AT THE PARIS EXPOSITION.

THIS pavilion is a picturesque little structure of varnished wood, decorated with panels of marquetry in mahogany, rosewood, etc., woods which form one of the sources of the riches of Nicaragua. The roof, which is gracefully curved, recalls slightly—without reproducing it—the roof of the palace of the colonies, at the *Invalides*. In fact, this pavilion is also the work of our *confrere*, M. Sauvestre. Notice the arrangement of the exterior staircase. M. Sauvestre, architect.—*La Semaine des Constructeurs.*



THE PAVILION OF NICARAGUA AT THE PARIS EXPOSITION.

THE PARIS EXHIBITION—GIRARD'S HYDRAULIC RAILWAY.

THE so-called sliding railway, to which a narrow slip of ground was assigned on the Esplanade des Invalides, at the back of the various colonial villages which have caused so much delight to millions of visitors, has attracted a very large amount of interest, although it was not completed and in working order until a comparatively short time since. Several causes have combined to make this curious exhibit an attractive one—its great novelty, the sanguine claims put forward by its exhibitor, the romance that is attached to its history, and the fact that no less a personage than Sir Edward Watkin has decided to give the system a practical and extensive trial in England. The name of Girard is still well known as that of a hydraulic engineer of considerable eminence; Girard was something besides this, an enthusiastic inventor, but not a practical man of business.

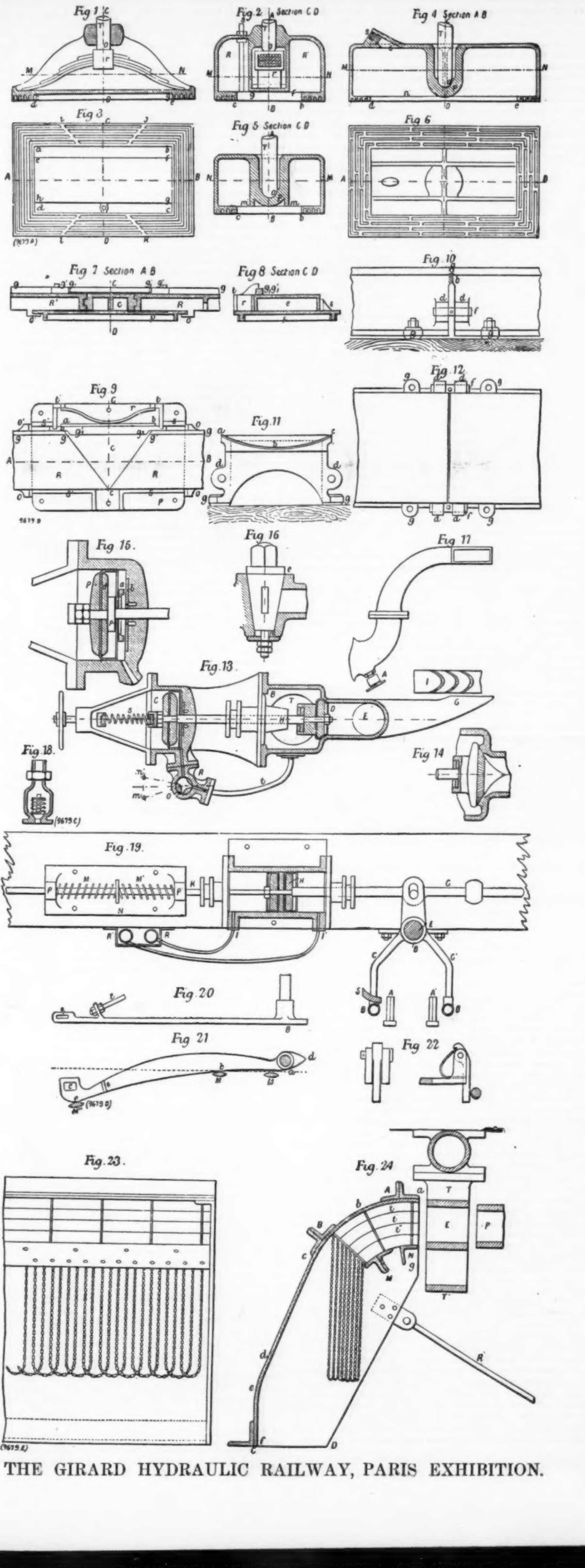
Nearly forty years ago, when the hydraulic engineering works of La Jonchere were flourishing under M. Girard's management and ownership, and just about the time when he was engaged upon constructing and erecting the turbines of the now famous chocolate factory of M. Menier, at Noisiel, the first idea of a railway system in which a new mode of propulsion might be given to railway trains occurred to him; this was no less than the substitution of a series of water jets issuing from nozzles standing up along the center of a railway track in such a way that the issuing streams could exert their effect on the under side of the carriages composing the train, and cause it to travel along the rails. This highly unpractical idea was supplemented some two years later, in 1854, by another still more revolutionary—the entire suppression of wheels, and the substitution of bearing plates which should be attached to the carriages and rest upon rails of a section specially designed to support them; further, in order to reduce the friction between the rails and the bearing plates, M. Girard proposed to maintain the two surfaces at some distance apart by means of compressed air when the train was in motion, so as to remove the friction between the surfaces. This proposition was on the face of it absolutely impracticable, but M. Girard continued to develop his original idea, and at the end of five or six years he produced an arrangement which to him at all events seemed full of promise, and in which a film of water maintained between the bearing plates and the rails was substituted for the cushion of compressed air; an experimental length of line which he constructed at La Jonchere gave some very curious results, and the inventor was further encouraged by the great interest which the emperor showed in his scheme. Whatever successful future there may be for the hydraulic railway in a perfected form, it is quite certain that in the hands of its original inventor no good results could have been obtained from it. M. Girard saw in his scheme, not a germ containing the spirit of a possible future success, but an already achieved and perfect result; he disdained the idea of practical experiments on a moderate scale, and refused the offer of assistance from England; the invention of a Frenchman should—in the first place at all events—benefit France only, and the system should be tried between two towns no less further apart than Calais and Marseilles.

With these ideas the reason is clear why M. Girard never advanced further than schemes on paper and his experimental line at La Jonchere; time went on and evil days came for France; a Prussian bullet in 1871 put an end to the hopes and the career of the inventor, and after peace was restored, the little that remained of M. Girard's works at La Jonchere was sold and scattered. Among the relics were all the documents relating to the inventor's cherished railway scheme, and these after having lain for some years in a garret were purchased by M. A. Barre, an old collaborator of Girard's, and who, like him, believed in the future of this scheme. But for want of funds the sliding railway would have formed one of the attractions of the great Paris exhibition of 1878, and possibly would ere this have again been consigned to oblivion.

M. Barre, however, found it impossible to gain sympathizers ardent enough to risk their money at that time. And so he waited for eleven years more, until, being more fortunate, he has been enabled to construct the experimental line which is now carrying many hundreds of passengers daily on the Esplanade des Invalides. Of course it was not only the expense attending the construction of the exhibit which has had to be met; for several years M. Barre has been engaged in making experiments and gradually changing and developing the primitive ideas of M. Girard until at the present time little remains except the original idea to be placed to the credit of the first inventor. The exhibit on the Esplanade des Invalides is wholly insufficient, both as regards its length and conditions of working, to demonstrate much in favor of the system for railway purposes; the utmost that it proves is a certain applicability for popular amusement, possibly a formidable rivalship to the favorite switchback railway.

Assuming, too, that the large claims for economy put forward could be substantiated, there would still remain a great number of practical difficulties to be overcome, and which, under ordinary circumstances, would seem to be insurmountable. When Sir Edward Watkin has constructed his trial line conclusive results will be obtained; till then the fullest credit for ingenuity may be freely accorded to M. Girard and M. Barre, and such a sphere of usefulness as that indicated above may be predicted for the hydraulic railway. In the meantime the subject is of sufficient interest for us to place before our readers a description of the system with some little detail.

In a few words, the general arrangement of the Girard-Barre hydraulic railway is as follows: On a pair of rails having a broad and flat top surface, and raised on a suitable structure some distance above the ground,



THE GIRARD HYDRAULIC RAILWAY, PARIS EXHIBITION.

is carried the train, the vehicles of which are supported on the rails by bearers, into which water under pressure can be forced, so as to lift the carriage off the rails and support it on a film of water; on the train are carried suitable arrangements for maintaining the supply for this purpose.

Along the middle of the track a pipe is laid from which at intervals project a series of standpipes terminating in suitable nozzles, controlled by valves; some of these nozzles point in one direction, and an equal number are directed the opposite way.

Immediately over these and extending longitudinally under the center of each carriage is a double line of pallets, set at reversed angles, and at such a height that one or other of the set of nozzles can discharge water against the pallets, the direction given to the train depending on which nozzles and pallets are in operation. The valves controlling the nozzles are closed and opened by the vehicles in passing.

In starting, the train is lifted from the rails by water being forced under the bearers, and a jet is projected against the row of pallets under the train which sets it in motion; after each carriage has traversed over the jet the valve is closed and the jet shut off, the adjoining one being opened and the train receiving a fresh impetus; in this manner the speed is maintained and accelerated by a succession of impulses.

The earlier form of bearers or slides adopted by Girard are shown in Figures 1, 2, and 3, annexed; they consisted of a box, R, containing a central compartment in which was placed the springs to which the carriage was suspended; the sides of the box contained air and water under pressure. The bearing face of the plate was grooved as shown, passages, I, being cut in the grooves to allow the surplus water to escape. This form was found to be very unsatisfactory, partly on account of the arrangement of the grooves and partly because of the position of the internal spring, which brought the plane of thrust, M N, below the point of support, O. The waste of water through the passages, I, was found to be very considerable.

Figs. 4 to 6 show the form of slide as actually in use on the experimental train at the exhibition, and of which four or six are secured to the sides of each carriage; it consists of a box in the center of which is a depression, P, that forms a step for the bearing rod, T, of the spring, the end of this rod being rounded so that a certain freedom of movement is given to the slide which enables the latter to accommodate itself to irregularities in the permanent way; the bearing surface is formed with grooves arranged as shown in Fig. 6, communication between these grooves being established by passages which are not directly opposite each other.

Water is admitted to the slide through the opening, S, and as it flows downward it can only escape by traversing the grooves in the bearing surface and by passing across the interrupted openings, with the result that the velocity of the water is gradually decreased, and there is less waste.

When the normal pressure is exerted against the rail and the slide, a film of water from one-half to three-quarters of a millimeter in thickness between the surfaces is maintained. It is evidently necessary that the rails over which these slides traverse should have perfectly true surfaces that should not be interrupted at any point, and which at the same time must be free to expand or contract.

The manner in which M. Girard proposed to get over this difficulty is shown in Figs. 7 to 9, in which the ends of two rails, R and R^1, are shown resting on a cast iron saddle, P; the ends of the rails were cut to angle as at G C and G^1 C, and the space thus formed was filled by the wedge-shaped piece, C, which was held in contact with the rails by means of the spring, R, but which was still free to slide with the dilatation of the rails.

This arrangement, ingenious as it was, was too obviously imperfect to be adopted, and the present method of joining the rails is shown in Figs. 10 to 12; by this arrangement a curved groove, ABC, is made in the end of each rail, and in this groove is placed a rubber fillet which has sufficient elasticity to allow for the variations in length of the rail arising from differences of temperature; the rails are secured together by the bolts, F, passing through the flanges, D; G G are holding-down bolts, securing the permanent way to the substructure; on the outer side of each rail a guard plate, not shown in the plan, can be attached to serve as a guide for the slides. The propelling mechanism of the train is illustrated by Figs. 13 to 18, and is practically the original arrangement suggested by Girard. It consists of three separate parts, in addition to the main running the whole length of the line, and the standpipes, which are connected to it at intervals; these parts are a valve chamber, B, a cylinder, C, and the automatic controlling valve, R. The water under pressure, which is to be used for propelling the train, flows up the standpipe, T, from the main laid in the center of the permanent way, and enters the valve chamber, in which is a valve, D, that closes the entrance to the nozzle, E, the pressure of the water at the back of this valve keeping it firmly shut; the spindle attached to the valve passes through a stuffing box, H, and beyond to the leather-packed piston in the cylinder, C, the diameter of which is slightly larger than that of the valve, B.

That part of the cylinder, C, beneath the piston can be put in communication with the valve chamber by means of the pipe, T, and the three-way valve, R; one of the openings in this valve is much larger than the two others, in order that the passage leading to the cylinder, C, may not be obstructed.

By the arrangement shown in Fig. 13 the water under pressure is delivered to the cylinder, C, and sufficient force is exerted to push forward the piston and with it to withdraw the valve, D, from its seat, allowing the water to rush through the nozzle against the row of pallets, I, beneath the carriage.

Levers are placed under the tender to open the valve, R, and to allow the water to escape until the impulse has been completed, when a corresponding lever at the other end of the train closes the valve and stops the jet until it is opened for a new impulse.

It is evident that double sets of such levers are necessary to operate both series of nozzles for driving the train in opposite directions. These will be described presently. The spring, S, assists in throwing back the piston, C, to its normal position, when the cylinder, C, receives no more water, but is put into communication

with the atmosphere through the small opening, O, that serves as a sort of hydraulic brake when the valve, D, returns to its seat.

This device for preventing shock to the various parts in movement was not found to be very satisfactory, and a valve of the form shown in Fig. 14 is substituted for the present arrangement, while the cylinder and piston, C, are modified as in Fig. 15; the chief alteration in the latter is the addition of the disk, P, which enters the recess, A, at the moment when the valve, D, is thrown on to its seat, the friction between the disk and the box checking the shock of the moving parts.

Fig. 17 illustrates the form of nozzle employed. The valve, A, which is introduced near the bottom, allows the nozzle to be emptied; the arrangement of this valve is shown in Fig. 18, where it will be seen that it is kept open by a spiral spring except when the water under pressure passes into the nozzle and forces the valve down, but as soon as this pressure is removed the valve opens and allows the contents of the nozzle to escape.

The foregoing are the principal special details of the system, but there are a number of minor devices which have been worked out with considerable ingenuity to overcome obvious difficulties connected with working. Thus, for example, in the event of a train being stopped by a signal, it might easily happen that the nozzle beneath one or more of the carriages has been opened and continues to discharge a jet of water against the pallets beneath the carriage.

In such a case two operations would be absolutely necessary: that of closing the valve immediately to prevent waste of water so long as the train remains standing, and of opening it again when the signal against the train is removed.

The arrangement adopted to meet this contingency is shown in Fig. 19, in which A and A^1 indicate the extreme positions of the valves connected with the nozzles of the line of standpipes. Outside of these, and running along the whole length of the train, are two iron tubes, B and B^1, suspended from the arms, C C^1, which are mounted on the shaft, E, that also runs along the whole length of the train, suitable couplings in all cases being provided between the carriages. Secured to the central crossframe under each carriage is the cylinder, H, with its piston rod, G, connected to the shaft, E, by means of a crank with a slotted pole and pin; openings are made at each end of the cylinder, H, connected, by means of the pipes, I and I^1, to other pipes, R R^1, that also extend throughout the train, terminating at the tender. The rod, K, passing through bearings, P P^1, in the bracket, N, carries midway of its length, between the bearings, a disk against which press the spiral springs, M M^1; according to whether movement is imparted to the piston, the spring M or M^1 is compressed. One end of each of the pipes, R R^1, terminates on the tender in a small receiver, and the whole system is filled with glycerine; the upper part of each receiver is in communication with a small reservoir charged with compressed air, the connection being controlled by means of a tap. The normal position of each of these two taps places the receivers in communication with the air, but if either one of them is turned, a passage is opened to the compressed air chamber, and the piston, H, is set in movement to the right or left together with the whole system of the shaft, E, and the rods, B and B^1, which in their movement open or close the valves of the nozzle. By the movement of the piston, H, the glycerine contained in that part of the system not under pressure is caused to rise in the receiver, and the spring M or M^1 is compressed.

After this operation has been performed, if the tap is again turned to its normal position, the piston, H, returns to the middle of the cylinder as soon as the compressed air escapes, the action of the spring and the difference of level of the glycerine in the two receivers being sufficient to overcome the weight of the different parts. It will be understood that this mechanism can be controlled from both ends of the train either to open or close the valves connected with each line of nozzles.

When a train is in motion, the jets upon which it depends for its speed are opened or closed automatically by a special mechanism placed at each end of the train, as already explained; four of these devices are therefore necessary, two for controlling the series of nozzles which propel the train in one direction, and the other two for actuating those which send the train in the opposite direction, and as it is absolutely necessary for this mechanism to work simultaneously, the actuating levers are connected electrically. The diagrams, Figs. 20 to 22, give an idea of the arrangement adopted for this purpose; as will be seen from Fig. 21, the arm that operates the valve of the nozzle (R, Fig. 13) has a parabolic working face, against which the lever of the valve comes in contact, the movement of the train causing the arm to pass over it gradually without any shock and forcing the valve lever to take the positions shown at M and M^2. The corresponding arm at the end of the train is arranged so as to give a reverse movement, bringing the lever of the valve from the position M^2 back to M, and thus shutting off the jet of water. All of the arms are arranged as shown in Fig. 20 to turn round the shaft, B, and they are stiffened by rods, T; the arms can be raised and lowered by a lever passing into the opening, C. Transversely the arms have a curved section as shown at S, Fig. 19, the center of this curve corresponding with that of the shaft, E. The same figure shows that the lever is placed above one of the lines of the tubes, B, so that both can act independently of each other on the lever of the valve, R (Fig. 13).

One obvious inconvenience from this system of propulsion is that due to the enormous amount of water projected from the nozzles, and which is supposed to be collected in a suitable channel made in the bed of the permanent way, either for running to waste or for being brought back to a pumping station. To overcome this difficulty the inventors have schemed a device for checking the spread of the water and directing it into the conduit; this is shown in Figs. 23 and 24, in which P is the mouth of the nozzle, E the line of pallets beneath the carriage, and the structure, A B C D, a curved apron placed on each side of the pallets and attached to the roadbed; as the line of pallets passes between these aprons the water is thrown from them to the right and left into the collector, the curved plates T, T^1, and T^2 being introduced to divide it, while its force is further broken by means of the rows of chains suspended from the bottom of the curve as shown.

A few words should be said about the means adopted for forcing water under pressure beneath the slides so as to raise the latter from the rails. It is claimed that for short runs up to 1,800 yards sufficient pressure can be obtained by carrying reservoirs charged with compressed air upon the tender, these reservoirs being recharged at each station. For longer journeys it is necessary to carry boilers, engines, and pumps for compressing the water, the reservoirs, which have to be of considerable capacity on account of the relatively large amount of water consumed, being kept filled from the waste water channel in the permanent way, while the train is in motion, by the ordinary water scoop. Several suggestions, more or less fanciful, are also proposed for utilizing the velocity of the train to store up the water at a sufficient pressure, and in this way to dispense with all compressing machinery; it may be mentioned that about 60 lb. per square inch are required to raise the slides from the rails.

We have endeavored to give as clear an idea as possible in the foregoing description of the very ingenious hydraulic railway, and for which both the original and the present inventor deserve great credit so far as ingenuity is concerned, but we must frankly state that in our opinion the credit that may be fairly claimed for them cannot be extended further. The most extravagant claims for capacity, speed, and economy of working are put forward for the system; it is admitted that the first cost of construction is higher than that of an ordinary railway running over level ground, but it is claimed that this economy disappears in hilly country because the hydraulic railway can be constructed almost as a surface line. But after the railway is built the economy—so it is asserted—becomes apparent in the most striking degree, the saving in traction expenses alone for coal being no less than 94 per cent.; in addition to this there is a total suppression of lubrication, and the maintenance of all the moving parts of an ordinary train, the absence of brakes give a further economy, and there is the saving of a large proportion of an ordinary railway staff, while the economy gained in the maintenance of carriages and locomotives, besides that due to the moving parts, is over 66 per cent. As for speed, it is asserted that 125 miles an hour can be readily obtained, while the absence of friction due to the fact that the train is always floating on a water film makes it possible to surmount any gradient with perfect ease and to pass around sharp curves. That all these claims and many others put forward by the advocates of this system are absolutely extravagant is too evident to demand any discussion. It is clear also that not only do the details of the mechanism at present employed fall far short of meeting the requirements of ordinary working, but also that a large number of practical and apparently insurmountable difficulties would be encountered—the freezing of the whole system in winter for example. It is gravely suggested that this difficulty can be overcome by using a mixture of glycerine and water in the proportion of one-fifth of the former to four-fifths of the latter.

We have given considerable space to this subject because it is a veritable mechanical curiosity, which has attracted a very large and in our opinion excessive attention, and because the name of one of our greatest railway magnates is now associated with it; the results that he will obtain with the experimental line he is about to construct will certainly be of considerable interest, while it is more than probable that Girard's hydraulic railway may, for purposes of public amusement, be made a very profitable undertaking, and may even find a limited application under exceptional circumstances for serious purposes, but it is not reasonable to suppose that the dreams of its inventors can be realized or their claims substantiated.—*Engineering.*

THE CHANNEL BRIDGE—PRELIMINARY DESIGNS.*

By Messrs. Schneider & Co., Creusot Iron Works, and H. Hersent.

Part I.

I.—INTRODUCTORY NOTICE.

The idea of connecting England with the Continent by a bridge is not new. It has from the beginning of this century occupied the minds of a great number of distinguished men, but the labors of M. Thome de Gamond particularly contributed to render the idea popular. Most of the schemes hitherto proposed have been insufficiently worked out. They have all been found impossible to execute, and for this reason have each, in succession, sunk in oblivion. The submarine tunnel was next thought of as the means of communication between France and England. The advocates of the bridge, however, have once more given the subject their attention, and the object of the present paper is to show that the construction of a bridge between France and England may now be considered capable of being carried out in practice. We may say that the problem is at present clearly placed before the technical authorities of both countries. However gigantic the undertaking, the many and various improvements which have been made in the art of bridge building fully warrant every hope of success in an attempt to turn out spans of metal 500 m. in length across the Channel, supported by columns resting at different depths on the bottom of the sea. The metal it is proposed to use is steel. The extensive use that has lately been made of this metal, both in France and abroad, notably in the Forth bridge, which is the outcome of the unmistakable progress of metallurgy, removes every doubt as to the feasibility of dispensing with about 50 per cent. in weight by the use of steel, while insuring the same degree of safety.

The preliminary projects submitted by MM. H. Hersent, Schneider & Co., and Fowler & Baker, consist of separate reports relating respectively to the foundations for the piers to be erected in the sea and to the construction of the superstructure, as well as of a rational statement of the means for placing in position the foundations and spans. The authors of these preliminary sketches do not wish to be understood as thinking no useful alterations can be made in their work when the time comes for the ultimate plans to be proceeded with. Whatever opinion may be formed of these projects, and whatever may be their eventual fate, their authors will at least have the gratification of having paved the way toward an undertaking of public interest and of having furnished data sufficiently minute and correct to enable the scheme to be submitted to the judgment and criticism of competent persons whose careful attention they solicit. Among the great undertakings which present a certain analogy to the proposed channel bridge, such as the opening of maritime canals, railways, ports, etc., none is to the same degree worthy either of the international interest which has guided the promoters of this great undertaking or the direct interest of the two countries that will not only be called upon to bear the cost, but will reap the advantages of the project as well. The amount of metal and machinery to be provided for the construction of a bridge over the channel would represent an aggregate weight of about 1,000,000 tons. The assumption is that each country will have to supply one-half of this amount, which on either side would for a lengthy period give a powerful impulse to the development of national industry. To estimate as precisely as possible the expense entailed by the construction of the channel bridge, it would be necessary to go further into the calculations and to modify, if necessary, after duly consulting the maritime interests involved in the question, the number of spans which might have a stretch of 500 m., as well as of the spans of shorter length required in various places. In the same way the extensions to be made in the port of Ambleteuse, and in an English port situated equally near to the bridge, will have to form the subject of a more detailed inquiry. An approximate idea, however, as far as can be possibly formed by a rough calculation at first sight, assuming that the distribution of spans shown* in Fig. 1 is adopted, permits the following figures to be given with reasonable certainty: 380,000,000f. for masonry supports and 480,000,000f. for the metallic superstructure, in all 860,000,000f., or £34,400,000. The works for the tunnel and the railways of both countries would have to be planned later on in agreement with the companies whose lines would lead up to the bridge. The time required for the completion of the undertaking may be fixed at about ten years.

II.—GENERAL DESCRIPTION OF THE BRIDGE.

Section 1. *Situation.*—The situation which seems preferable for a bridge connecting England with the Continent is, as it were, suggested by nature herself, namely, by the line stretching over the shallowest parts of the channel, and connecting the shores where they are closest to each other. This line commences at a point near to Cape Grisnez and reaches the coast of England near Folkestone, passing over the banks of Colbart and Varne. This arrangement has been adopted in order to enable the existence of these two banks to be taken advantage of, so as to avoid working in great depths, and thereby to diminish the height of the piers to be erected. The banks are situated near the center of the channel, about 6 kiloms. apart. The depth of water at that point does not exceed 7 m. or 8 m. at low water, and they are separated from each other by a depression about 25 m. to 27 m. deep. Between the banks of Varne and the British coast the depth does not exceed 29 m., but between that of Colbart and the Cranaux-Oeufs the bottom sinks somewhat abruptly down to 40 m.; it then attains 55 m. about midway across, when it begins gradually to rise. In these parts then the chief difficulties would be encountered in laying the foundations. The sketch submitted gives about the shortest distance available for the ready connection of the existing lines of railway in both countries, without difficulty or an unusual amount of work.

Section 2. *Masonry supports. Preliminary project by H. Hersent.*—In contemplating the construction of the supports, the nature of the bottom was the first thing that demanded attention, as it was necessary to ascertain whether its formation and resistance would be sufficient to insure the stability of the structure; the next thing to be considered was the form to be given to the supports, so as to obtain as large a surface as possible at the base, without causing trouble from the effect of the ebb and flow of the tides; and lastly, it was found necessary to foresee the difficulties that may be encountered in an undertaking of this nature in order to determine the measures to be taken for successfully grappling with them. The result of repeated experiments is that the ground is found to be sufficiently solid to support very extensive works. In addition, the borings lately made in connection with the proposed channel tunnel have confirmed the results of the preceding experiments as to the position and the nature of the bottom, as published by M. Thome de Gamond. More precise inquiries will be necessary when the works are proceeded with, as regards each pier, in order to be in a position to solve each detail beforehand. At present, however, there is no doubt that the ground is capable of supporting a load of from 10 to 12 kiloms. per square centimeter, as is often found to be the case on a foundation less solid than that afforded by the white and blue chalk which everywhere forms the channel bottom. The soft parts of the surface in contact with the water and the strata of sediment and sand that may cover the bottom at certain points, especially near the shores, will have to be removed in order to lay the piers on more solid foundation. Each supporting pier will consist of a block of masonry of good material, set with Portland cement mortar, and laid on the sea bottom; their surface above high water level will form the foundation for the metal columns which serve as direct supports of the spans of the bridge, and will measure 650 square meters. They will, moreover, have a batter of about 1 in 10 up to the foundation caisson, which is flanged in order to increase the surface of the base in contact with the surface of the ground. The piers will form a rectangle, 25 m. in length, and their width will have to be suited to each system of columns. This rectangle will terminate in semicircles, so as to oppose the least possible resistance to the currents. Supposing 55 m., the surface of the base of the piers in contact with the ground will be 1,604 square meters. Where the depth is less, the surface will be proportionately smaller. Up to a certain height, the brickwork will extend over the whole surface of the

* A paper read at the meeting of the Iron and Steel Institute, Paris, 1889.—*From the Engineer.*

* The horizontal scale of the bridge elevation diagram, which must be taken as Fig. 1, is $\frac{1}{12500}$; the vertical scale is $\frac{1}{1250}$, and the plan is on the same scale as the elevation. The dimensions of the caissons, Figs. 3, 4, 5, and 6, are given in meters. Plans of the caissons are given at Figs. 7, 8, and 9.

THE PROPOSED CHANNEL BRIDGE.

DESIGNED BY MESSRS. SCHNEIDER & CO. AND M. H. HERSENT; SIR JOHN FOWLER AND MR. BENJAMIN BAKER, MM. INST. C.E., CONSULTING ENGINEERS.

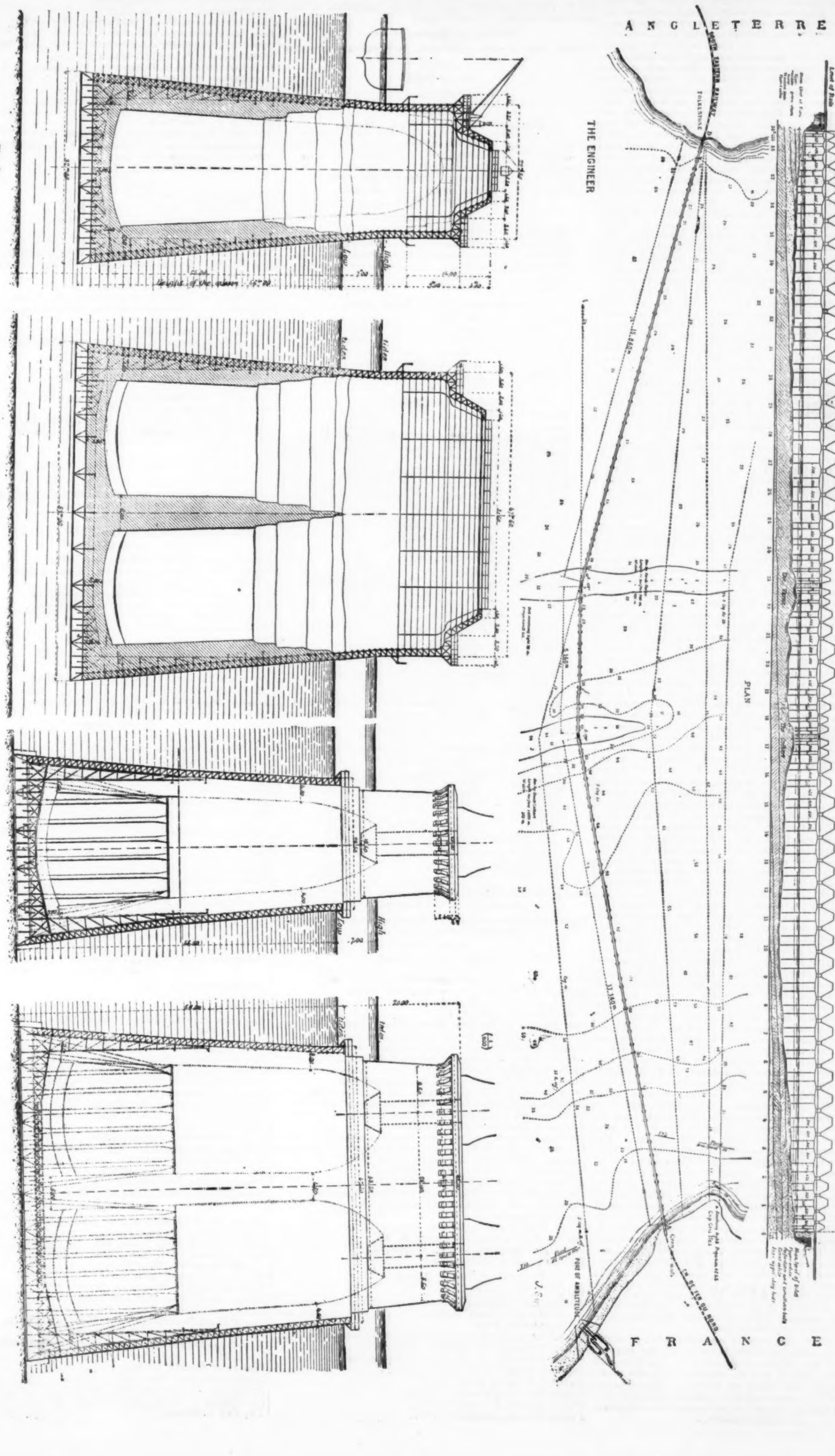


Fig. 3

Fig. 4

Fig. 5

Fig. 6

base, while two recesses will be provided in order to decrease the load upon the foundation, the sections of the walls being of sufficient strength to resist any additional loads. The masonry will be built inside metal caissons similar to those used for ordinary bridge piers, and forced down by compressed air down to the solid ground. These caissons, which will be surmounted by metal cases surrounding the masonry, will serve to float the piers until they touch the ground. This will enable the ground to be carefully cleaned, and promote the application of the concrete that is to be interposed between the masonry and the bottom, as will be explained further on. The caisson will, moreover, be surmounted by a movable dome, which will be removed when the upper part of the column is completed, so as to enable the masonry to be carefully finished with squared stones above the level of low water. Special arrangements will be made for joining the columns to the masonry, so that these joints may be at all times readily inspected to ascertain whether anything is out of order in each separate portion of the work. The whole of the pillars will occupy a little over one-twelfth of the section of the channel. This reduction of the section of the channel is not likely to exercise a notable influence on the erosion of the bottom, or to bring about an appreciable increase of the speed of the flood and ebb tides. The distance between the piers, fixed at 500 m. and 300 m. for the large spans, will not be less than 200 m. and 100 m. respectively for the small ones, and will, at all events, be sufficient to prevent their proving an obstacle to the free navigation of sailing vessels. As regards steamships, no such danger is to be apprehended, as the current, which would certainly become a little faster in the center of the open spans, would carry floating bodies, even disabled vessels, toward that part, and prevent their ever touching the bridge. It may, therefore, be reasonably admitted that, owing to these distances and dimensions, the piers would in no way modify the conditions of navigation in the channel, and would certainly not constitute an appreciable obstacle to navigation in general.

Section 3. The metallic superstructure. Preliminary project by Messrs. Schneider and Co.—The metal columns are firmly placed upon the platforms of the supporting piers of masonry. They are of a distinctly cylindrical shape, and vary in height between 40 m. and 42·780 m., and on them will be placed the main girders of the bridge. There will thus be between the lower parts of the beams and the level of the sea at low water a free space varying in height between 61 m. and 63·780 m., which height at high water will be reduced to 54 m. and 56·780 m. respectively. This height is amply sufficient for the passage of vessels of whatsoever description or tonnage. By placing the floor upon vertical cylindrical columns, the space above indicated, of a minimum height of 54 m., is kept throughout the whole width of the span—a result which has not been achieved in the bridge of similar dimensions that is now being constructed over the Forth estuary. In the Forth, in fact, the height at the center of the structure above the high water level is 45·60 m., but this height does not extend beyond the central third of the span. At the two thirds near the ends this space greatly diminishes, until it is actually reduced to a height of scarcely 15 m. near the pier. In order to make the exigences of navigation agree as far as possible with the economical carrying out of the preparatory works, three different lengths of span have been proposed. No. 1, alternate spans of 300 m. and 500 m.; No. 2, alternate spans of 200 m. and 350 m.; No. 3, alternate spans of 100 m. and 250 m. The largest spans correspond to the greatest depths, the smallest to the most elevated parts of the sea bottom and to the parts near the shores. The system of girders to be employed is simple, unlatticed, trussed, so as to ensure the distribution of all stresses. The secondary beams provided are intended to reduce the length of certain members, to prevent buckling of braced beams and to give those employed as struts proportions suitable to the lengths concerned, whereby it becomes possible to leave the coefficient of compression, which would increase the weight, out of consideration.

The level of the permanent way is 72 m. above the low water level. This height might have been reduced by arranging the permanent way in the lower portion of the bridge, but in that case it would have been necessary to make the cross beams a great deal larger, and consequently heavier. By raising the permanent way, on the contrary, as it is proposed here to do, a marked economy is attainable, which will certainly not be absorbed by increased expenses involved by the necessity of erecting viaducts at both ends of the bridge. There will be a double set of rails, and the width of the flooring proper will be 8 m. The whole width of the bridge is variable. The greatest distance between the axes of the main girders is 25 m., such a space being necessary to ensure the stability of the structure under the action of violent gusts of wind. The roadways are of the ordinary width of 1·50 m. between the axes and the rails. The latter will be set in grooves to obviate accidents. The floor, made of ribbed sheet iron, is to cover the bridge throughout its length, so as to make every part accessible to the men appointed for the supervision of the bridge. Between and outside the roadways pavements are provided for the men to stand on, and thus keep out of the way of passing trains. Upon the flooring it will be possible to establish "refuges," stations for the guards, signal boxes, switches, etc. All these arrangements may be multiplied according to the requirements of the traffic, and scattered over any convenient points and spans. On the piers lighthouses may be erected, to indicate obstacles to be avoided. The various kinds of lights used in lighthouses may also serve to indicate to shippers the distance from the Colbart and Varne banks. It would have been easy to establish a bridge with four lines of rails instead of two, but the probable development of the traffic did not appear to warrant any increase of outlay in that direction. The provision of a road for ordinary vehicles is also superfluous, as goods will always be carried by rail.

To meet objections from a military point of view, arrangements could be made for making the span at either end of the bridge unfit for use; the two end spans notably, which are in contact with the abutments, might be removable or revolve. The detailed description of the plans and methods of construction it is proposed to adopt forms the subject of the following chapters. (*To be continued*).

THE PARIS EXHIBITION.

List of awards to citizens of the United States, September 29, 1889. Specially compiled for the Scientific American from the official list of awards.

Group I.—Works of Art.

CLASSES 1 AND 2.—OIL PAINTINGS, PICTURES AND DESIGNS.

CLASS 1.

Grand Prize.

Melchers.

Gold Medals.

Harrison. Jarnefeld. Vail. Wecke.

Silver Medals.

Boggs.	Bridgmann.	Chace.
Davis.	Dewiney.	Donoho.
Gay.	Harrison, Birge.	Howe, W.
Knight.	Mac Ewen.	Mosler.
	Reinhart. Weir.	

Bronze Medals.

Allen, W.	Blashfield.	Cox.
Delachaux.	Dodge.	Farny.
Fowler.	Guthery.	Innes.
Johnson, E.	Minor.	Moore.
Peters.	Simmons.	Thompson.
Ulrich.	Vonnoh.	Walker.

Supplementary List of Bronze Medals.

Beckwith.	Bell, Ed.	Blum.
Brandgee.	Butler.	Coffin.
Dana.	Forbes.	Gardner, Miss.
Gaul.	Gifford.	Hassans.
Jones.	Klumpke, Miss.	Patrick.
Richards.	Story, J. K.	Thayer.
	Truesdell.	

Honorable Mention.

Breck.	Bristol.	Brown, J. G.
Butler.	Curtis.	Denman, H.
Dow, Arthur W.	Gross.	Haas, F. H. De.
Hayden.	Henry.	MacEntee, Jervis.
Meys, W. De.	Nicoll.	Parton, E.
Plume.	Shirland, Walter.	Theriat.
Turner.	Vedder.	Whiteman.
	Whittredge. Wyant.	

CLASS 2.

Gold Medals.

Arbey. Reinhart.

Silver Medals.

Blum.	Low.	Remington.
Rolshoven.	Sherwood, Miss.	Whitemore.

Bronze Medals.

Cox, Kenyon. Weir.

Honorable Mention.

Drake.	Greatorex, Mlle.	Pennel.
	Wiles, Irving.	

CLASS 3.—SCULPTURE AND ENGRAVING ON MEDALS.

Bronze Medals.

Kitson.

Honorable Mention.

Adams. Ruggles, Mlle. Theo. A. Warner.

CLASS 5.—ENGRAVING AND LITHOGRAPHY.

Gold Medals.

Kingsley, Elbridge.

Silver Medal.

Closson, W. B.

Bronze Medals.

Aikman, W. M. Putnam, S. G.

Honorable Mention.

Davidson, H. Kruell, G. Wolf, Henry.

Group II.—Education and Instruction—Materials and Processes of the Liberal Arts.

CLASS 6.—EDUCATION OF CHILDREN—PRIMARY INSTRUCTION—INSTRUCTION OF ADULTS.

Grand Prize.

Boston Public Schools.

Gold Medals.

Bardeen, C. W. & Co., Syracuse, New York.
Barnes, A. S. & Co., New York.
Public Library, Chicago, Ill.
National College for Deaf Mutes, Washington, D. C.
Industrial School for Indian Children, Carlisle, Pa.
Sockanosset School for Boys, Howard, R. I.
Education and the Common School Education.
Public Schools of Elizabeth, N. J.
Bureau of Public Instruction, Sacramento, Cal.
Department of Public Instruction, Des Moines, Iowa.
Department of Public Instruction, Harrisburg, Pa.
Commissioner of Schools, Columbus, Ohio.
Bureau of Education, Madison, Wis.
Perkins Institute for the Blind, Boston, Mass.
Ivison, Blakeman & Co., New York City.
Journal of Education and the American Teacher.
Lippincott, J. B. & Co., Philadelphia, Pa.
Merriam, G. & C. & Co., Springfield, Mass.
National Bureau of Education, Washington, D. C.
Public Schools of the City of Pittsburg, Pa.
Popular Education.
Silver, Burdett & Co., Boston, Mass.
The Chatauqua Circle, Syracuse, N. Y.
Public Schools of the City of Buffalo, N. Y.
Public Schools of Moline, Ill.

Silver Medals.

Betz, Carl, Kansas City, Mo.
Academic and Popular Branch of the Public Libraries of Poughkeepsie and Buffalo, N. Y., and Woburn and Somerville, Mass.
School for the Blind and Deaf Mutes at Colorado, Col.
School for the Feeble Minded, Elwyn, Pa.
School for the Feeble Minded, Columbus, Ohio.
School for Deaf Mutes, Scranton, Pa.
Public Schools, Woburn, Mass.
Public Schools, Galveston, Texas.
Public Schools, Columbus, Ohio.
Public Schools, Cincinnati, Ohio.
Public Schools, Chicago, Ill.
Public Schools, Cambridge, Mass.
Public Schools, New Haven, Conn.
Public Schools, Sandusky, Ohio.
Superintendent of Public Instruction, Denver, Col.
Department of Public Instruction, Lansing, Mich.
Superintendent of Public Instruction, Baltimore, Md.
Department of Public Instruction, Dakota.
Department of Public Instruction, Providence, R. I.
Christianson Institute, Brooklyn, N. Y.
House of Refuge, Randall, N. Y.
Home for Imbecile Children, Santa Clara, Cal.
Orphanage and House of Correction, Coldwater, Mich.
Pratt, D. C., New York.
The Hyatt School State Co., Bethlehem, Pa.
The American Journal of Education, St. Louis, Mo.
The School Journal, New York.
The Academy, Syracuse, N. Y.

Bronze Medals.

Berkeley School, New York.
School for Deaf Mutes, Faribault, Minn.
Public Primary Schools, Coldwater, Mich.
Public Schools, Rimersburgh, Pa.
Public Schools, Omaha, Neb.
Department of Public Instruction, New Hampshire.
Department of Public Instruction of N. H., and Concord, New Hampshire.
Bureau of Instruction, Columbia, S. C.
Department of Public Instruction, Austin, Texas.
Department of Public Instruction, Salem, Oregon.
Illinois School Journal.
Intelligence, Chicago, Ill.
The Ohio Educational Monthly and National Teacher, Akron, Ohio.
The Teacher, New York.
The Educational News, Philadelphia, Pa.
Wilson.
School for Deaf Mutes, Salem, Oregon.
French Infant School, New York.
Free School for Young Girls, New Orleans, La.
Public Schools of Lewiston, Maine.
Public Schools of Fort Worth, Texas.
Harwod & Co.
Institute of Our Mother of the Sacred Heart, Washington Heights, D. C.

CLASS 7.—ORGANIZATION AND MATERIALS USED IN SECONDARY INSTRUCTION.

Grand Prize.

Bureau of Education, Department of the Interior.

Gold Medals.

Department of Public Instruction, Iowa.
Department of Public Instruction, Massachusetts.
Public Schools of Galveston, Texas.
Department of Public Instruction, California.
Department of Public Instruction, Wisconsin.
Public Schools of Boston.
Public Schools of Pittsburg.

Silver Medals.

Ginn & Co.
Heath, D. C. & Co.
Lake Erie Seminary (College for Young Men).
Mt. Holyoke Seminary.
Ogontz College for Young Men, Pennsylvania.
St. Stanislaus Commercial College.

Bronze Medals.

Public Schools of Moline, Iowa.
Van Norman Institute, New York.
City of Coldwater, Michigan.

Honorable Mention.

Betz, Carl.
Dummer Academy, South Byfield, Mass.
East Florida Seminary, Gainesville, Fla.

CLASS 8.—ORGANIZATION, METHOD AND MATERIALS FOR HIGHER INSTRUCTION.

Grand Prizes.

Bureau of Ethnography, Washington, D. C.
Bureau of Education, Washington, D. C.
Geological Commission, Washington, D. C.
War Department, Washington, D. C.
Rensselaer Polytechnic Institute, Troy, N. Y.
Meteorological Service, Washington, D. C.
Smithsonian Institution, Washington, D. C.
Johns Hopkins University, Baltimore, Md.
University of the State of New York.

Gold Medals.

Cornell University, Ithaca, N. Y.
Cope, E. D.
Naval School.
American Natural History Museum, New York.
University of Virginia.

Silver Medals.

Amherst College, Amherst, Mass.
College of Physicians and Surgeons, Baltimore, Md.
Eclectic Medical College, Cincinnati, Ohio.
College of Pharmacy, Massachusetts.
College of Pharmacy, Philadelphia, Pa.
Polyclinic College, New York.
American School at Athens.
National School of Jurisprudence.
American Antiquarian Society, Worcester, Mass.
Washington Lee University.
Princeton College, New Jersey.
Vassar College, Poughkeepsie, N. Y.
Saint John's College, Annapolis, Md.

Honorable Mention.

Library of the Institute of Law, Chicago, Ill.
Public Library, Omaha, Neb.
Public Library of St. Louis, Mo.
Public Library of Woburn, Mass.
Brown University, Providence.
Mercantile Library, New York.
Wellesley College, Wellesley, Mass.
Dartmouth College, Hanover, N. H.
La Fayette College, Easton, Pa.
The William Norman Library, Woodstock, Conn.
Mt. Holyoke Seminary, Massachusetts.
American Archeological and Numismatic Society, New York.
Historical Society, Buffalo, N. Y.
Historical Society, New Haven, Conn.
Society for the Instruction of Women.
St. Stephen's College, Annandale, N. Y.
The Pax University.

CLASSES 6, 7, AND 8.—TECHNICAL INSTRUCTION.

Gold Medals.

Eastman College, Poughkeepsie, N. Y.
Manual Training School, Philadelphia, Pa.
Manual Training School, St. Louis, Mo.
Massachusetts Institute of Technology, Boston.

Silver Medals.

Cooper Union, New York.
Free Evening Industrial Drawing School, Boston, Mass.
Stevens Institute of Technology.
University of Illinois.

Bronze Medals.

Alabama Polytechnic Institute.
Lehigh University.

CLASS 9.—PRINTING AND PUBLISHING.

Grand Prize.

The Century Company.

Gold Medals.

Appleton, D. & Co., New York.
Houghton, Mifflin & Co., Boston, Mass.
Lippincott, J. B. & Co., New York.
Merriam, G. C. & Co., Springfield, Mass.
New York Bank Note Company, New York.

Silver Medals.

Barnes, A. S. & Co., N. Y. — Barrie, George.
Dodd, Mead & Co., N. Y. — Estes & Lauriat.
Gebbie & Co. — Gebbie, Hasson & Co.
Ginn & Co. — Ivison, Blakeman & Co. N. Y.
Johns Hopkins University Publication Agency.
Lothrop, D. & Co. — Wiley, John & Sons.
Williams, David.

Bronze Medals.

Baird, Henry Carey & Co. — Howard Lockwood & Co.
Lindsay, Robert M. S. — Macclury, A. C. & Co.
Orange Judd & Co. — The Publishers' Weekly.
Rand, McNally & Co — University Publishing Co.

Honorable Mention.

The American Bookseller. — Armstrong & Knauer.
Barden, C. W. — Brentano, A.
Fishel, Adler & Schwartz. — Gallison & Hobron Co., The.
Heath, D. C. & Co. — Knox, Thomas W.
Mitchell, I. I. & Co. — Poor, H. V. & H. W.
Stokes, Frederick A. — Taintor Bros. & Co.

CLASS 10.—STATIONERY, BINDING, AND ARTISTS' MATERIALS.

Grand Prize.

Fairchild, Leroy W.

Gold Medals.

Brown, L. L. — Warren, S. & D. & Co.

Silver Medals.

Carter, Dinsmore & Co. — Stafford, S. S.

Bronze Medals.

Caw's Ink and Pen Co., N. Y. — Waterman, L. E. & Co.

Honorable Mention.

Little, A. T. — Nassau Manufacturing Co.
Philadelphia Novelty Manufacturing Co.
Rogers Stamp Company.
The Case, Lockwood & Brainard Company.
Weeks & Campbell.

CLASS 11.—APPLICATION OF THE ARTS OF DRAWING AND MODELING.

Gold Medals.

Prang & Co. — Tiffany & Co, New York.

Silver Medals.

Baldwin, Gleason & Co., Limited.
Lowell, John A. & Co. — Rath, A.

Honorable Mention.

Harris, Nathaniel R.

CLASS 12.—PHOTOGRAPHIC PROOFS AND APPARATUS.

Grand Prize.

United States Geological Survey.

Gold Medals.

Barker. — Eastman & Co. — Rowland.
University of California.

Silver Medals.

Alman, Louis. — Baldwyn, Coolidge.
Clark, V. R. — Guerin, F. W.
Scholten, John A. — Stein.
Tabor, H.

Bronze Medals.

Landy, James. — Seavey, Lafayette W.
Marx. — Thors.
Society of Amateur Photographers of New York.

Honorable Mention.

Beal, J. H. — Bloch. — Cox, G. C.
Lyold. — Ryder, E. — Smith & Pattison.
Wood, G. B.

CLASS 13.—MUSICAL INSTRUMENTS.

Silver Medals.

Bohman, Joseph. — Weber, Albert.

CLASS 14.—MEDICINE AND SURGERY—VETERINARY MEDICINE.

Silver Medals.

Frees, G. A. — Seabury & Johnson.

Bronze Medal.

Pomeroy Truss Company.

CLASS 15.—INSTRUMENTS OF PRECISION.

Grand Prize.

Naval Observatory, Washington, D. C.
Rowland.
Signal Service of the Federal Army.

Gold Medals.

Darling, Brown & Scharps. — Hollerith.

Silver Medal.

Tacher.

CLASS 16.—CHARTS AND APPARATUS FOR GEOGRAPHY AND COSMOGRAPHY, TOPOGRAPHY—STATISTICS.

Grand Prize.

Corps of Engineers, United States Army.
United States Coast and Geodetic Survey.
United States Signal Service, War Department.
United States Geological Survey.

Gold Medal.

Lesley, J. P.

Silver Medals.

Chamberlin. — Colvin, Verplanck.
Cook, G. H. — Hull, James.
Rand, McNally & Co. — Winchell.
Whitehouse.

Honorable Mention.

Department of Agriculture, Washington, D. C.
Foote, Albert Edward. — Hydrographic Office.

Group III.—Furniture and Accessories.

CLASS 17.—CHEAP FURNITURE AND FANCY FURNITURE.

Gold Medal.

Heywood Bros. & Co.

Silver Medals.

Brunswick-Balke-Collender Co.
Derby & Kilmer Desk Company.

Bronze Medals.

Cutler, A. & Son. — Merklen Bros.
Marks Adjustable Folding Chair Company.

CLASS 18.—UPHOLSTERY AND DECORATION.

Silver Medals.

American Braided Wire Company.
Hartford Woven Wire Mattress Company.

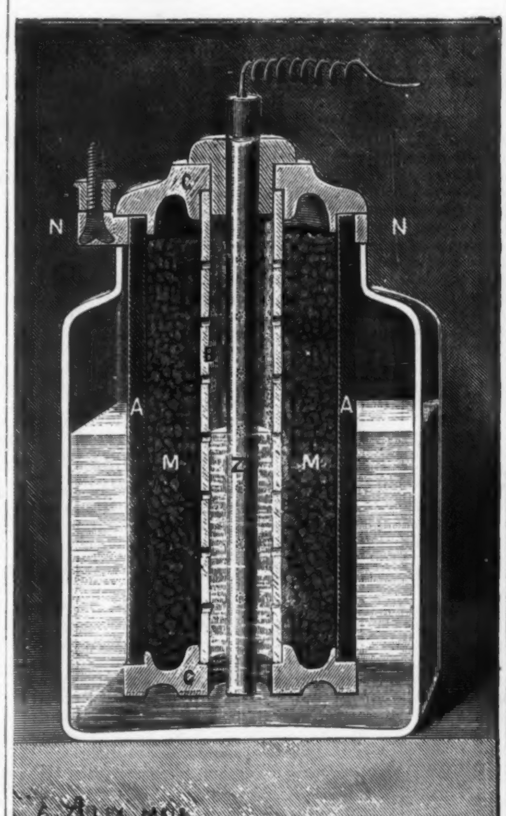
Honorable Mention.

Evanhoe, Frank N. — Knitted Mattress.

(*To be continued.*)

THE LACOMBE BATTERY.

A NEW form of agglomerate cell has been introduced by Messrs. Lacombe & Co., of Paris and London. In



THE LACOMBE BATTERY.

this the usual position of the zinc is reversed. The zinc is placed in the center in a small porous tube. Outside is a porous carbon cylinder which acts as one pole, and the depolarizer of coke and manganese peroxide is packed in between. It offers some advantages over the usual form with porous pot, and has achieved considerable success in France, where it is now largely used. The arrangement adopted causes the hydrogen as it arises to cross the depolarizer, and the small distance to the zinc also reduces the internal resistance. The battery is stated to give an undiminished E.M.F. for a much longer period than the old form and to have given very favorable result in practice. It seems a compact and serviceable form of battery.

CONTRIBUTIONS TO THE CHEMISTRY OF STORAGE BATTERIES.*

By E. FRANKLAND, D.C.L., F.R.S.

UNDER this title I communicated to the Royal Society, in February, 1883,† the results of some experiments on the reactions occurring during the charging and discharging of a storage cell. I showed that no appreciable part of the storage effect was due to occluded gases, as had been previously suggested by some chemists and physicists; but that the act of charging consisted essentially in the decomposition of lead sulphate, while the discharge was produced by the recomposition of this salt.

The establishment of these, as practically the only reactions going on in a storage cell, enabled me to prescribe a very simple method by which the charge in any cell could be ascertained, for as sulphuric acid is liberated during the charging and absorbed by the active material of the plates during discharge, the amount of charge could at any time be measured by ascertaining the amount of free sulphuric acid in the cell; in other words, by simply determining the specific gravity of the electrolyte; and this method has since been very generally adopted by the users of storage batteries.

In continuing these experiments it soon became evident that the lead sulphate formed and decomposed in the cell could not be the ordinary white sulphate hitherto known to chemists, because, in the first place, the active material of the plates always remains colored, even after discharge; and secondly, because whenever white sulphate is produced through abnormal reactions in the cell, it is afterward decomposed only with extreme difficulty by the electric current.

In order to obtain some light upon the composition of the sulphate formed and decomposed in the cell, I have studied the action of dilute sulphuric acid upon litharge and minium.

Action of Dilute Sulphuric Acid on Litharge.

Finely powdered litharge was treated with successive portions of dilute sulphuric acid until the liquid remains strongly acid after prolonged trituration. The resulting insoluble buff-colored powder was washed with water till free from acid, and dried first at 100°C. and afterward at 150°–160°. The loss at this higher temperature was less than 0·2 per cent., and was therefore due to hygroscopic moisture.

PbO and SO_3 were then determined in the dried compound as follows: This salt was dissolved in a small quantity of pure concentrated solution of caustic potash, and the solution after dilution was saturated with CO_2. (According to H. Rose, COPbo" is soluble in $COKo_2$, but not in COHoKo.) Any excess of CO_2, which might have caused the COPbo" to dissolve, was avoided by warming the liquid with the precipitate on the water bath to a temperature at which the COHoKo begins to dissociate. The liquid was then allowed to cool and stand twelve hours before filtering. The COPbo" was filtered off, converted into nitrate, and precipitated and weighed as sulphate. The sulphuric acid was determined in the filtrate from the COPbo".

1·2964 grammes of the salt gave 0·6647 gramme baric sulphate and 1·4437 grammes plumbic sulphate.

These numbers agree closely with the formula—

$$(^3{}_2(SO(PbO)_5,$$

as is seen from the following comparison of calculated and experimental numbers;

	Calculated.		Found.
$3SO_3$	240	17·71	17·61
5PbO	1,115	82·29	81·96
	1,355	100·00	99·57

These analytical results suggest the following graphic formula:

$$\begin{array}{ccccc} PbO_2 & & & & PbO_2 \\ \| & & & & \| \\ S & = O_2 = & S & = O_2 = & S \\ \| & & \| & & \| \\ PbO_2 & & PbO_2 & & PbO_2 \end{array}$$

The formation of this salt may be represented by the following equation:

$$\underset{\text{Litharge.}}{5PbO} + \underset{\text{Sulphuric acid.}}{3SO_4H_2} = \underset{\text{Buff lead salt.}}{S_3Pb_5O_{14}} + \underset{\text{Water.}}{3OH_2}$$

Action of Dilute Sulphuric Acid on Minium.

Minium was treated with dilute sulphuric acid in exactly the same way as litharge, and the resulting brownish red compound dried first at 100° C. and afterward at 150°–160°. The loss at this higher temperature was again less than 0·2 per cent.

PbO, SO_3, and excess of oxygen were then determined in this salt in the following manner: The salt was first treated with concentrated hydrochloric acid in order to reduce all the lead to the non-oxide stage. The resulting mixture was then dissolved in caustic potash and treated as already described. The excess of oxygen was determined by finding the loss of weight which resulted from the evolution of CO_2 when the salt was treated with oxalic acid and dilute nitric acid.

2·1136 grammes of the salt gave 1·1978 grammes baric sulphate and 2·2710 grammes lead sulphate.

1·5110 grammes treated with oxalic acid and dilute nitric acid evolved 0·0910 gramme CO_2.

These numbers correspond to the following percentages:

SO_3	19·45
PbO	79·03
O	1·09
	99·57

which agree with the formula—

$$S_2Pb_3O_{10}$$

as is seen from the following comparison:

	Calculated.		Found.
S_2	64	7·57	7·78
Pb_3	621	73·49	73·36
O_{10}	160	18·94	18·43
	845	100·00	99·57

The composition of this salt may be represented graphically thus:

$$\begin{array}{lcccc} & & O & & \\ & & \| & & \\ Pb < O_2 = & & S & = O_2 = & Pb \\ < O_2 = & & S & = O_2 = & Pb \\ & & \| & & \\ & & O & & \end{array}$$

The formation of this salt is expresseed by the following equation:

$$\underset{\text{Minium.}}{Pb_3O_4} + \underset{\text{Sulphuric acid.}}{2SO_4H_2} = \underset{\text{Red lead salt.}}{S_2Pb_3O_{10}} + \underset{\text{Water.}}{2OH_2}$$

These, then, are the salts which constitute the original active material of storage cells when that material is formed by the admixture of sulphuric acid with litharge or minium respectively, and it is highly probable that one or the other of these salts takes part in the electrolytic processes of the storage battery. It is fortunate that these hitherto unknown salts (and not the ordinary known sulphate) are formed in the cell

* A paper read before the Royal Society, June 20, 1889.

† *Proceedings* of the Royal Society, vol. xxxv., p. 67.

reactions; for, in the alternative case, lead storage batteries would be practically valueless.

If the buff lead salt be the active material of the battery plates, then the following equations express the electrolytic reactions taking place in the cell:

I. In charging—

(*a.*) *Positive Plates.*

$$S_3Pb_5O_{14} + 3OH_2 + O_4 = 5PbO_2 + 3SO_4H_2$$

Buff lead salt. Water. Lead peroxide.* Sulphuric acid.

(*b.*) *Negative Plates.*

$$S_3Pb_5O_{14} + 5H_2 = 5Pb + 3SO_4H_2 + {}_2OH_2$$

II. In discharging—

(*a.*) *Positive Plates.*

$$5PbO_2 + 3SO_4H_2 + 5H_2 = S_3Pb_5O_{14} + 8OH_2$$

(*b.*) *Negative Plates.*

$$5Pb + 3SO_4H_2 + O_4 = S_3Pb_5O_{14} + 3OH_2$$

If the red lead salt be the active material, then the following equations express the same electrolytic reactions:

I. In charging—

(*a.*) *Positive Plates.*

$$S_2Pb_3O_{10} + O_2 + 2OH_2 = 3PbO_2 + 2SO_4H_2$$

Red lead salt. Lead peroxide. Sulphuric acid.

(*b.*) *Negative Plates.*

$$S_2Pb_3O_{10} + 4H_2O = 3Pb + 2SO_4H_2 + 2OH_2$$

II. In discharging—

(*a.*) *Positive Plates.*

$$3PbO_2 + 2SO_4H_2 + 2H_2 = S_2Pb_3O_{10} + 4OH_2$$

(*b.*) *Negative Plates.*

$$3Pb + 2SO_4H_2 + 2O_2 = S_2Pb_3O_{10} + 2OH_2$$

An inspection of these equations discloses, in the case of the red lead salt, a fact which has already been roughly observed in practice, viz., that only half as much active material is electrolytically decomposed on the negative as on the positive plates; whence it follows that the weight of active material on the negative plates need not exceed one-half of that upon the positive plates; for, in the decomposition of the electrolyte, equivalent quantities of oxygen and hydrogen are evolved—that is to say, two atoms of hydrogen for each atom of oxygen. But in the decomposition of the red lead salt, four times as many atoms of hydrogen are required to reduce the salt to metallic lead as atoms of oxygen are necessary to transform the lead of the salt into peroxide. When, however, the active material of the positive plate has once been converted into peroxide of lead, it seems probable that the red salt only is formed; at all events, until the discharge at a high potential is nearly completed, when there are indications of the production of the buff colored salt. But this is a point requiring further investigation.

I have to thank Dr. F. R. Japp, F.R.S., for his assistance in the analytical work of this investigation.

* Mr. Fitzgerald considers that this peroxide is hydrated.

THE PICTET ICE MACHINES.

AMONG the most interesting as well as the most improved of the mechanical applications to be seen at the Paris exposition are the ice machines of the Pictet company.

A very complete collection of these machines is in continuous operation, producing ordinary opaque ice, and ice in blocks, as transparent as that met with in nature, and cold air for cooling reservoirs, halls, or factories.

The process employed in these different applications is based upon the expansion of anhydrous sulphurous oxide under pressure and previously cooled, for the cold produced by such expansion is equal to the heat lost by the gas during its compression.

The quantity of cold produced is directly proportional to the power of the pump and to the weight of the liquid evaporated.

The theoretical apparatus consists of four principal parts, as follows: (1) A refrigeratory, containing anhydrous sulphurous oxide; (2) a force and suction pump; (3) a condenser; (4) a regulating cock.

The construction of the machine and its mode of operation are very simple. The liquid to be volatilized is put into a copper cylinder protected against humidity and the air. At this moment the sulphurous oxide exerts no refrigerating action. Then a portion of the vapors is removed with a pump. This diminution of pressure permits the liquid to expand and to volatilize spontaneously, and, as it has been explained, this volatilization permits it also to absorb the heat contained in the bodies placed in contact with the refrigeratory and to convert it into the state of latent heat.

After the sulphurous oxide has absorbed the heat of the surrounding bodies, it is forced by means of a pump into a condenser, where it is brought back to the temperature of the surrounding water, that is to say, to a moderate temperature, at which it liquefies and can pass again into the refrigeratory to be volatilized anew, through a diminution of pressure, and thus produce cold indefinitely.

Figs. 1 and 2 allow the principle of this machine, as well as the *modus operandi*, to be understood. The refrigeratory, E, is placed horizontally in a tank in which an incongealable liquid (solution of chloride of magnesium) circulates. The ice moulds may be placed either in this receptacle or in a distinct one.

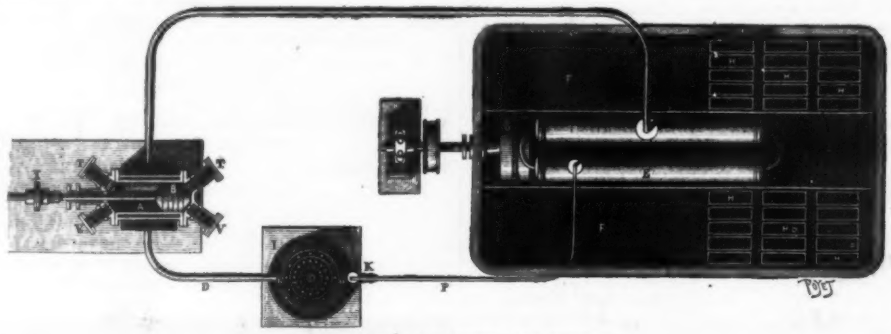


FIG. 2.—PLAN OF THE MACHINE.

T, suction valve; V, compression valve; X, junction of the piston of the motor with the compressing piston.

The sulphurous oxide is volatilized in E through the action of the pump, A, which sucks up the acid into the refrigeratory through the pipe, C. This change of state produces an intense cold, which is communicated to the surrounding liquid. The pump afterward forces the vapor back into the condenser, I, through the pipe, D. The condenser consists of a system of copper tubes. A current of cold water flows constantly within these tubes, and outside in a double jacket. This water absorbs the latent heat that the vapor contains and condenses the latter. The pipe brings back the liquid sulphurous oxide to the refrigeratory, where it is volatilized anew, and a cock, K, regulates its flow.

The compression pump, A, is a double-acting one, and is of cast iron. The piston is of metal and is provided with segments. It operates very smoothly, owing to the lubrifying properties of the sulphurous oxide.

It is easily understood that the water in the moulds in the tank, F, becomes congealed and converted into blocks of ice through the cold saline water that circulates in the tank, for such water is reduced to a temperature several degrees lower than the freezing point of water. It will likewise be seen that there is no contact of chemical products of gases capable of coloring the ice or imparting taste or smell to it. If the water used is pure, the ice also will be pure. The dimensions of the blocks of ice obtained vary according to need.

Artificial Production of Cold in Breweries.—The most important application of artificially produced cold is certainly that found in breweries, on account of the increasing development daily taking place in the manufacture of beer. In order to realize a regular production of the latter, and to obtain a beer of good quality and capable of being preserved, we know that it is necessary that the fermentation of this beverage shall proceed under perfectly defined conditions of temperature that are only realizable through an energetic and continuous cooling of the liquids under treatment.

Up to recent years, the manufacture of beer, especially of lager, has remained the almost exclusive monopoly of northern countries. These breweries have employed ice collected from lakes or from meadows flooded during the winter, and stored up in immense ice houses. Ice brought by ships from the northern seas likewise has permitted of combating the heat of summer when the supply contained in the ice houses has become exhausted. But the increase in the production of beer on the one hand, and the frequency of mild winters on the other, has rendered mishaps too frequent, and the quality of the product suffers therefrom too directly to allow this industry to rely upon natural ice alone in the future. Machines for producing ice artificially have for several years permitted of remedying this capital inconvenience, and now it may be said that, owing to their powerful aid, the manufacture of beer is unlimited.

Moreover, it is in southern countries, in warm climates, where the hygienic influence of this beverage is to be desired, that the manufacture can be entered upon under conditions of economy and entire security, owing to ice machines.

We shall not enter into all the details of beer manufacture, but shall merely recall the fact that, when the brewing descends either from the tuns or from a hop filter tub, its temperature at certain seasons of the year may be, in the first case, still 30°, and, in the second, generally above 60°.

Before barreling, it is therefore necessary to proceed to a cooling and oxygenation of this mash in a refrigeratory, first with ordinary water as cold as possible, and then with ice water, when it is a question of low fermentation.

The various systems of apparatus for thus producing cold or ice water differ from each other only in the facility with which they effect this renewal of heat, in the economical conditions in which they realize it, in the simplicity of their operation, and in the security that they should present.

The anhydrous sulphurous oxide machines have the advantage that they require no special apprenticeship on the part of those who operate them, that they can be set running or be stopped, as often as may be desired, without there being any particular maneuver to to be performed, and, finally, that there is no danger of explosion or of fire. The first applications of apparatus of this kind in the manufacture of beer simply

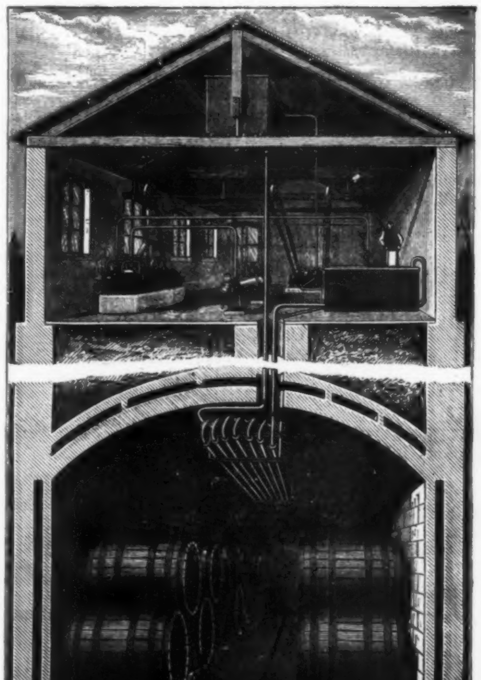


FIG. 3.—COOLING OF STORAGE CELLARS.

consisted in the making of artificial ice, which was substituted for the natural article in the various operations where the latter had been used. This was an innovation that lowered the net cost and presented a complete security for a brewery located far away from cold countries, but, nevertheless, one that was attended with the drawbacks inherent to the use of natural ice.

Not only do special apparatus in which there is a circulation of incongealable liquid, and which will be described further along, permit of furnishing all the cold water or ice water necessary for the refrigeration of the brewing, but also that necessary for maintaining a low temperature in fermentation.

The progress realized by the use of ice machines consists in the direct utilization of the cold produced without passing through any intermedium. The appa-

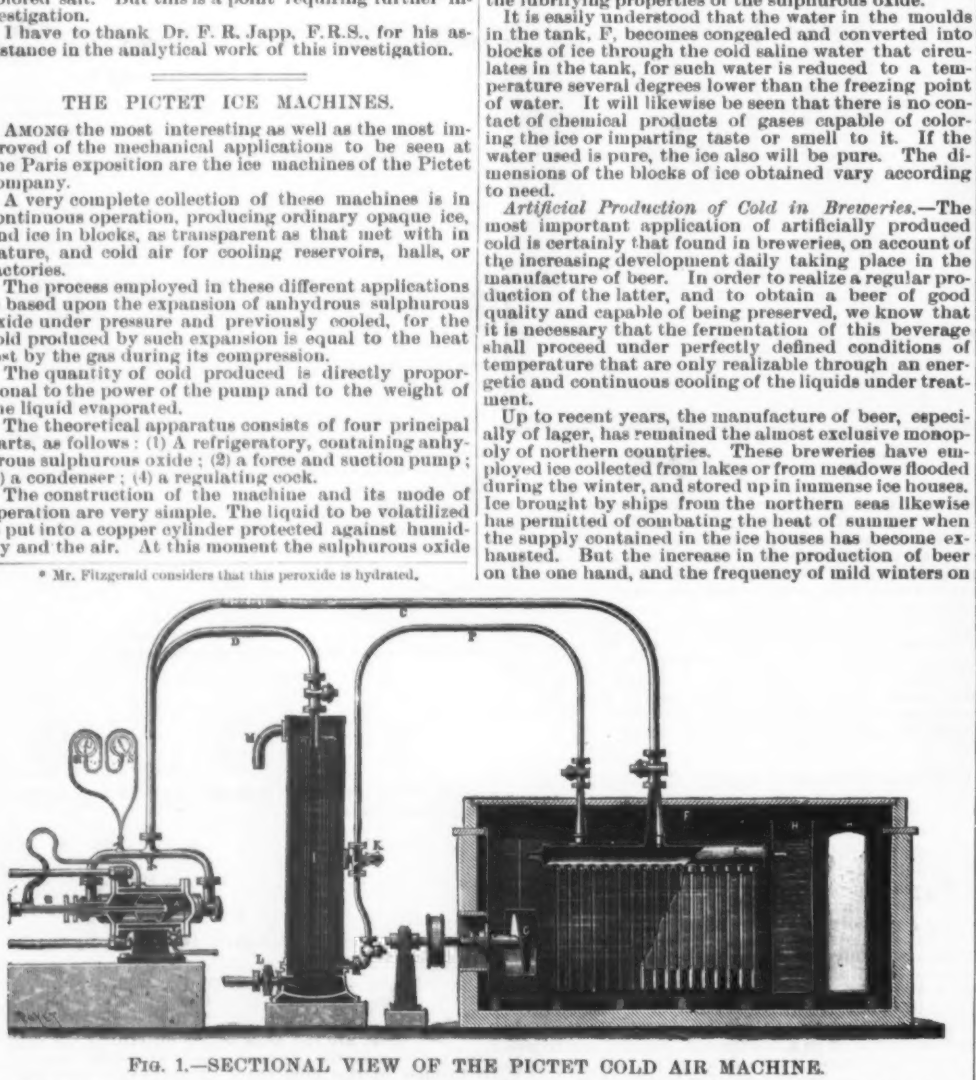


FIG. 1.—SECTIONAL VIEW OF THE PICTET COLD AIR MACHINE.

A, compression pump; B, compressing piston; C, pipes through which the gaseous sulphurous oxide is sucked; D, pipes through which the same is forced; E, refrigeratory; F, freezing tank; G, helix; H, ice moulds; I, condenser; K, regulating cock; L, cock for the inlet of water of condensation; M, overflow pipe; P, pipe through which the liquid sulphurous oxide returns; R and S, suction and compression manometers.

ratus absorbs the heat in measure as it manifests itself in the beer in fermentation.

"Cooling by a circulation of incongealable liquid" is the definition that well characterizes this kind of installation.

The ice apparatus properly so called is situated in that part of the brewery most favorable for proper surveillance, and in proximity to the steam generator, if it has its special motor, and as near as possible to the latter, so that the same engine man can easily run it.

The circulatory apparatus cools the surrounding air in the cellars or rooms that contain the backs or the casks filled with beer (Fig. 3).

The ice apparatus is then reduced to its simplest expression. It consists exclusively of the sulphurous oxide compression pump with its pressure gauges, the refrigeratory, the condenser, and the cock that regulates the return of the liquefied sulphurous oxide to the refrigeratory. The latter is immersed in a tank of very small size, which contains the incongealable solution of chloride of magnesium designed to be the vehicle of the cold.

A stirring helix makes the liquid circulate very rapidly through the system of tubes, in order to assure of an energetic exchange of temperatures.

The cooled incongealable liquid, which represents a capacity of about one heat unit per degree of heating for each quart in motion, is sent to all points of the brewery at which a low temperature must be maintained. A pump takes up the incongealable liquid from the congealing tank and sends it to circulate in a series of iron coils placed at the upper part of the room to be cooled, whence it returns anew to the congealing tank, after leaving in its travel a part of its cold in the rooms traversed. Returning to the tank, the incongealable liquid becomes cooled anew, in order to be taken up by the pump again and sent into the coils.

As the hot air in the cellars always tends to ascend to the ceiling, it comes into contact with the very cold (− 6° to − 7°) coils, and becomes cooled and leaves upon the coils the humidity (in the form of rime) with which it was charged, and there is thus obtained in the entire room a temperature equal to that of an air at once cold and dry, this being a desideratum in brewing. The intensity of the circulation is so regulated that at the end of its travel the incongealable liquid has become heated to a temperature of about 4° or 5° C. It then flows into a collecting tank, whence a pump takes it and returns it to the refrigerating tank of the Pictet apparatus. Here it abandons its heat to the sulphurous oxide refrigeratory, and, reduced to the desired temperature, begins again the motion just described. Usually, the extreme temperatures of this kind of circulation are − 6° on starting from the refrigerating tank, and − 1° on the return.

This system necessarily comprises a particular mode of isolating the rooms from the external temperature, for they are at a very low temperature, and would become rapidly heated were not some elementary precautions taken, such as to have double doors and to isolate the walls, etc.

FIG. 4.—COOLING OF FERMENTING TUBS.

One of the advantages of this method of cooling is that there is thus avoided all condensation of steam and all humidity on the surface of the fermenting tuns, since the surrounding air is always cold, and, consequently, at a lower point of saturation than that which corresponds to the temperature of the tuns. This is very important for the homogeneousness of the fermentation. Injurious germs are, in fact, sometimes deposited upon the surface of the liquid when the temperature of the tuns, lower than that of the surrounding air, leads to a condensation of a part of the steam that it contains and which is always more or less miasmatic.

The principal advantage of this system is the great saving in manual labor, since there is no longer any carrying of ice to be done.

Moreover, the cooling action may be perfectly regulated by the maneuver of properly arranged cocks, that permit of controlling the activity of the circulation of the incongealable liquid at any point that may be designated and at any moment that may be desired.

By a nearly analogous process, it is likewise possible to effect the cooling in the very beer itself, as shown in Fig. 4. This system consists in directing to all points of the brewery, where cooling is to be effected, ordinary water that has been reduced to a temperature of +1° by means of the ice machine.

The Pictet ice machine comprises the same parts as the preceding, and nearly all brewers now use the two methods concurrently, that is to say, the cooling of the storage and fermenting cellars by a circulation of incongealable liquid, and the direct cooling of the fermentations by soft water reduced to a temperature of +1°. Here again it is a solution of chloride of magnesium that circulates among the pipes of the refrigeratory; but this cold incongealable liquid also acts immediately upon the ordinary water contained in a tank parallel with the congealing tank and traversed by a coil in which circulates, by means of a pump, the incongealable liquid, which returns to the tank as before.

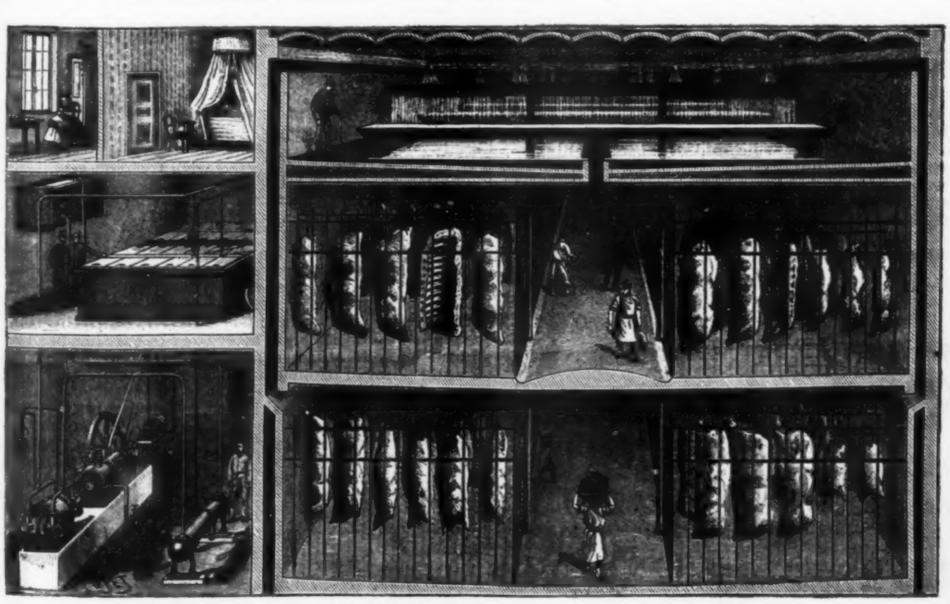


FIG. 5.—PRESERVATION OF MEAT BY COLD.

What characterizes this mode of circulation is that the cooling of the brewings is obtained directly, the temperature of the surroundings being merely an accessory consequence of the temperature of the tuns or of the casks containing the beer. The water at +1° circulates in "swimmers" or attemperators immersed in the liquid under fermentation. The exchange of temperatures is energetically effected, and the surface of this apparatus may be reduced to very small proportions.

Cold Storage Depots for Meat and other Food.—The process of cooling that we have just seen applied to storage cellars may likewise be applied to the preservation of meat or other alimentary products liable to spoil quickly at the ordinary temperature. In fact, it suffices to inclose these products in a properly arranged room, and to place at the upper part a number of tubes in which the refrigerating liquid is made to circulate at a temperature as low as may be desired, since the Pictet machines are capable of practically furnishing a temperature of —30°.

But, besides such an arrangement, which is very simple and easily applied, either in storehouses or on board of ships, the Pictet society employs the Schroederer process, the first application of which was made at the abattoirs of Geneva, and has given excellent results.

Pipes placed at the upper part of the building (Fig. 5) had the incongealable liquid at as low a temperature as is judged useful. Orifices in these pipes allow the liquid to flow into a trough containing small apertures after the manner of a colander. The cold liquid then falls in a shower into another trough, whence it is taken in order to be led around the refrigeratory and to return, cooled anew, through the same conduits.

The air of the place to be cooled rises through flues in the walls and is brought into contact with the refrigerating liquid. Its density increases and causes it to flow through the lower part of the cold chamber, whence it makes its exit through conduits formed in the flooring and is distributed throughout the preserving rooms. This air, reheated in contact with the provisions to be cooled, rises toward the cold chamber, and so on. At the end of a very short time, a normal system is established and brings the rooms to a temperature that can be easily varied between 0° and —10°.

Abattoirs provided with these storage chambers are installed in several cities, and in Switzerland the cities of Geneva, Carongo, and Vevey have already had recourse to the Pictet cold air machines for the preservation of meat.

We have pointed out the most important applications of the artificial production of cold, but there are others still that have caused great progress to be made in certain industries. We may mention in particular the application of cold in chocolate and stearine manufacture, in the manufacture of certain chemical products, in the rectification of alcohol, in the preservation of silkworm cocoons until the leafing of the mulberry, in the manufacture of ice on shipboard, in the concentration of mineral waters, in the preservation of milk, in the manufacture of margarine, in the extraction of paraffin from petroleum, in the driving of wells and tunnels in aquiferous earth, etc.

The Pictet society owes the creation of a large demand for its apparatus in all these branches of industry exclusively to the quality of the machines that it constructs, to the particular care with which each part of the machines is made, and to the progress that is daily being accomplished.

Thus, in the new refrigeratory, E (Figs. 1 and 2), that has just been patented in France and foreign countries, the company has endeavored to combine an emissive surface of a maximum caloric with the use of a minimum quantity of volatile liquid, and has obtained such a result perfectly by using U shaped tubes fixed in a vertical position to the main part of the apparatus, which consists of two large horizontal copper cylinders. These U-shaped tubes thus form a communication between the two cylinders, and the volatile liquid is kept at the same level in them. The apparatus, which is wholly of copper, consists of two cylinders about six inches in diameter and of a length that varies with the size of the apparatus, and which serve as collectors and vapor domes.

In order to increase the surface of emission of the vapors, and, at the same time, to establish an equilibrium of the pressures above the two branches of the communicating tubes, these collectors are connected at the ends by curved tubes. The communicating tubes start from the bottom of the collectors, and are held by a soldering of tin in ferrules brazed to the collectors.

This arrangement makes the joints perfectly tight and firm. The U-shaped tubes may be easily put in place and removed without injury to the neighboring solderings.

In order to increase the surface of emission without increasing the internal volume of the apparatus, the tubes are joined to each other in their straight part by copper bands which, carefully soldered, permit of the transmission of heat, at the same degree as transmitted by the tubes themselves. This mode of construction, and this arrangement, has the advantage of preventing the bursting of the refrigerating tubes through congelation, in case the agitation of the incongealable liquid should happen to cease for some reason or other. Besides, as the emission of the vapors of the volatile liquid is more easily produced, there is a certain diminution in the motive power employed for suction. Finally, the level of the volatile liquid can be lowered in the refrigeratory to a considerable degree without the performance of the apparatus being sensibly diminished.

In order to utilize the cold produced by the evaporation of the sulphurous oxide, the refrigeratory is placed in a large rectangular tank. A very brisk circulation of water containing chloride of magnesium in solution is kept up continuously by the operation of a helix situated at one end of the refrigeratory.

Two tight vertical partitions oblige the current of saline water produced by the helix to pass between the tubes and around the external surface of the refrigeratory. Apertures at each extremity of the partitions permit the water to pass into the refrigeratory and to make its exit behind the helix in order to circulate around moulds placed in the tank.

Particular attention, too, has been paid to the pump, the operation of which consists in compressing the vapors taken from the refrigeratory and in liquefying them in the condenser. It is to the permanen-

cy of the perfect working of this that is due the permanency of the constant production of ice.

The pump chamber is a double-jacketed cylinder, whose dimensions are proportional to the size of the machine. The cast iron piston is adjusted carefully and is polished within the cylinder. It presents a wide surface of contact within the inside of the cylinder, and, in order to secure as perfect hermeticalness as possible, is provided with a series of parallel grooves. It is provided, besides, with two steel or cast iron segments. The grooves serve especially to increase the effect produced by the successive expansions of the gases, which flow from one groove to the other through very small annular orifices.

The cocks placed upon the refrigeratories and condensers are of a special type, with the object of completely preventing leakages after the cocks have been placed definitely in position, and whether they are open or closed (Fig. 7). To this effect, the shell is closed on one side and the tightening of the plug in it is effected with a threaded ring which bears directly upon the nut. An intermediate ring which carries two snugs prevents the key from turning when the threaded ring is tightened or loosened. A cap provided with a leather joint closes the interior of the shell hermetically when the maneuvering of the cock is finished.

As regards the chemical cooling agent, sulphurous

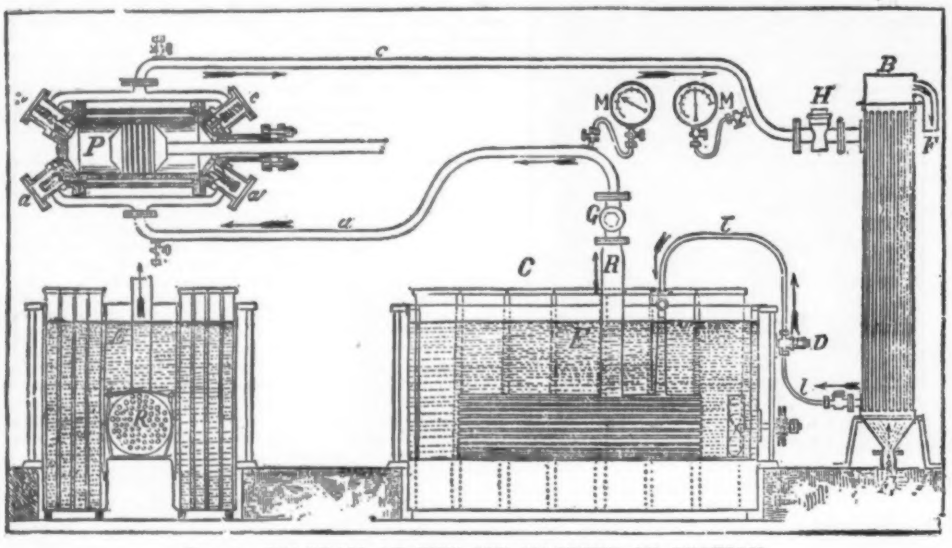


Fig. 6.—DIAGRAM OF THE ICE MACHINE IN SECTION.

P, sulphurous oxide pump; *a*, suction valves; *c*, delivery valves; H, condenser cock; M, force and suction manometers; B, condenser; F, pipe for leading water to and from the condenser; J, pipe for returning sulphurous oxide from the condenser to the refrigeratory; D, regulating cock; R, collector of the refrigeratory; E, incongealable water; C, tank filled with moulds; G, refrigeratory cock; I, pulley for actuating the helix.

The clacks have been long studied, and their special construction is the result of several years of experience. Their distinguishing characteristics are as follows: The body of the valve is of steel, and the rod is quite thick and the disk is resistant. The guide is as long as required by the external box, which is of bronze and protects all the mechanism of the clacks.

The spring that acts upon the valve rod is very long—at least twenty times longer than its stroke. The suction spring is weak, and the pressure that it exerts when at rest is $\frac{1}{10}$ of an atmosphere upon the surface of the obturating disk. The seat of the suction valve forms a piece with the guide and screws into its box. The clack is stopped in its travel by a cross bar, which prevents it also from falling into the cylinder in case it should break. The feeble power with which the spring of the suction valve acts is a condition of its proper working, for the gases sucked up by the pump enter this cylinder so much the more easily in proportion as they meet fewer obstacles. The tension of the spring is regulated by means of a nut placed upon the valve rod. The tightening must be so done that on holding the clack vertically, disk downward, the spring shall support just the weight of the clack, so as to keep it against its seat. It is necessary that the least pressure exerted upon the top of the rod shall immediately bend the spring, and that the latter shall bring back the clack in contact with its seat as soon as the pressure is removed.

The delivery valves are constructed upon the same

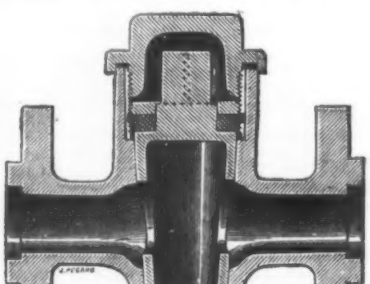


Fig. 7.—TYPE OF COCKS USED IN THE PICTET ICE MACHINE.

principle as the suction valves, and are characterized by the same arrangements. The spring, however, although very long with respect to the travel of the valve, is much stronger than the suction one. Its tension is regulated by means of a bronze sheath which is screwed upon its guide.

The stuffing box in the machines is divided into two parts: A metallic lining composed of spring segments establishes a joint between the piston rod and the interior of the cylinder, and in front of it there is a cast iron ring. After the latter comes a cavity that is filled with soap-stoned cords. The cast iron ring that closes the entrance of the stuffing box, by bearing upon the stuffing, is provided with a groove over which there is a rubber ring. When the tightening has been effected, this ring is compressed against the sides of the box and prevents leakages at the side.

oxide, the company manufactures that itself at its Authy works. The product manufactured here is stored up in immense reservoirs of a capacity of 13,000 pounds, whence it is taken and delivered to commerce in siphons like those used for mineral waters, where it is a question of small quantities, and in copper cylinders when the quantity to be delivered is large. These cylinders, which are more especially designed to supply ice machines, contain, according to circumstances, from 110 to 220 pounds of sulphurous oxide. They are provided with a special fastening device designed to permit of easy carriage, without danger, and, at the same time, to allow of their being easily emptied.

Fig. 8 represents the system employed. At III. it may be seen that the external cock, B, is fixed to the extremity of a bent tube which runs to the side of the cylinder, and thus permits, owing to the internal pressure, of the exit of the liquid without turning the cylinder.

At IV. the tube is below the liquid, thus permitting either the latter or the gas to make its exit. The cock, B, is a screw one of special form which has been adopted by the company as giving, as regards tightness, better results than any of the other models that it has tried.

The screw thread at the base of the cock corresponds to a coupling attached to a lead tube. This latter is screwed to the regulating cock (Figs. 1 and 2) on the one hand, and to the cylinder cock on the other, and establishes a momentary communication between the sulphurous oxide reservoir and the ice machine. A copper cover, A, of cylindrical form is screwed over the stop cock, and serves as a protection to the entire system. Should the internal cock show the least leak, the second joint would serve to prevent the loss of gas. A screw plug, C, is always placed at the extremity of the cock coupling. At III. (Fig. 8) it will be seen that

Fig. 8.—SULPHUROUS OXIDE CYLINDER.

when this coupling is directed upward, the discharge tube runs to the bottom of the cylinder, and *vice versa*.

In this short review of the Pictet ice machines, we have had to pass rapidly over the various parts that compose it. But, upon examining all these parts, one cannot help being struck with the degree of improvement made and with the profound study that has presided in the execution of the smallest of the parts of this relatively new apparatus.

It is owing to the quality of its machines that the company has taken the first rank in its special industry, for the machines that it has thus far furnished are now producing an average of 88,000 pounds of ice per hour, without taking into consideration the countries in which it has sold the right to work its patents, and in which the artificial manufacture of ice is conducted on a large scale.—*Le Genie Civil.*

THE INVENTOR'S WIFE.

By T. E. Corbett.

It's easy to talk of the patience of Job. Humph! Job had nothin' to try him;
Ef he'd been married to 'Bijah Brown, folks wouldn't have dared come nigh him;
Trials, indeed; now I'll tell you what—ef you want to be sick of your life,
Just come and change places with me a spell—for I'm an inventor's wife.
An' sech inventions! I'm never sure, when I take up my coffee pot,
That 'Bijah hain't been "improvin'" it, and it mayn't go off like a shot.
Why, didn't he make me a cradle once that would keep itself a-rockin'?
And didn't it pitch the baby out, and wasn't his head bruised shockin'?
And there was his "patent peeler," too, a wonderful thing, I'll say;
But it had one fault—it never stopped till the apple was peeled away.
As for locks, and clocks, and mowin' machines, and reapers, and all sech trash,
Why, 'Bijah's invented heaps of 'em, but they don't bring in no cash.
Law, that don't worry him—not at all; he's the aggravatinest man—
He'll set in his little workshop there, and whistle, and think, and plan,
Inventin' a jew's harp to go by steam, or a new-fangled powder horn,
While the children's goin' barefoot to school, and the weeds is chokin' our corn.
When 'Bijah kep' me company, he warn't like this, you know;
Our folks thought he was dreadful smart—but that was years ago.
He was handsome as any pictur' then, and he had such a glib, bright way—
I never thought that a day would come when I'd rue my weddin' day;
But I've been forced to chop the wood, and tend to the farm beside,
And looked at 'Bijah a-settin' there, I've just dropped down and cried.
We lost the hull of a turnip crop while he was inventin' a gun;
But I counted it one of my mercies when it bu'st before 'twas done.
So he turned it into a "burglar alarm." It ought to give thieves a fright;
'Twould scare an honest man out of his wits, ef he sot it off at night.
Sometimes I wonder ef 'Bijah's crazy, he does sech curious things.
Hev I told you about his bedstead yet? 'Twas full of wheels and springs;
It had a key to wind it up, and a clock face at the head;
All you did was to turn them hands, and at any hour you said,
That bed got up and shook itself, and bounced you out on the floor,
And then shet up, jest like a box, so you couldn't sleep any more.
Wa'al, 'Bijah, he fixed it all complete, and sot it at half-past five,
But he hadn't more'n got into it, when—dear me, sakes alive!
Them wheels began to whizz and whirr; I heard a fearful snap,
And there was that bedstead, with 'Bijah inside, shet up, jest like a trap.
Is creamed, of course, but 'twan't no use. Then I worked thet hull long night
A-trying to open the pesky thing. At last I got in a fright;
I couldn't hear his voice inside, and I thought he might be dyin',
So I took a crowbar and smashed it in. There was 'Bijah peacefully lyin',
"*Inventin' a way to get out agin.*" That was all very well to say,
But I don't believe he'd have found it out ef I'd left him in all day.
Now, sence I've told you my story, do you wonder I'm tired of my life,
Or think it strange ef I often wish I warn't an inventor's wife?
—*Roller Mill.*

OZONE AND ETHYLENE.

The experiments of Hautefeuille and Chappuis have proved that ozonized oxygen condenses to a dark blue liquid under a pressure of 125 atmospheres and at the temperature at which ethylene evaporates under the atmospheric pressure, namely —102·5°. Since the ozone remains in a liquid state after the pressure has been reduced to that of the atmosphere, it follows that the boiling point of ozone cannot be very much lower than that of ethylene.

Consequently Olzewski attempted to obtain liquid ozone by cooling ozonized oxygen to —150° at the ordinary atmospheric pressure. But though the receiver was cooled to —157° by liquid ethylene, no liquefied ozone was obtained, the result being due evidently to the large quantity of oxygen with which it mixed. But by using liquid oxygen at atmospheric pressure in place of ethylene, the temperature being now —181·4°, the ozone was easily obtained in the form of a dark blue liquid. If by injecting the ozonized oxygen into a tube thus surrounded with liquid oxygen at this temperature a drop of liquid ozone was formed, the author observed that on allowing the oxygen to evaporate, the influx of gas being stopped, the ozone remained liquid until the whole of the oxygen had evaporated. When this point was reached, the temperature would be about — 150°. At the boiling point of oxygen, the ozone remained a liquid, which was transparent in thin layers, but almost opaque in a layer 2 mm. thick. To determine the boiling point of the ozone, the tube containing it was placed in liquid ethylene at —140°. The ozone remained liquid until the ethylene had nearly reached its boiling point, when the temperature of its evaporation was noted on a sulphurous oxide thermometer and found to be — 109°, corresponding to —106° on the hydrogen thermometer. Hence this temperature, —106°, may be taken as the boiling point

of liquid ozone. On evaporation the ozone became a bluish gas, which readily recondensed in liquid ethylene.

The author has succeeded in solidifying liquefied ethylene by inclosing it in a tube surrounded by liquid oxygen, this tube being itself surrounded with liquid ethylene. It was found to solidify at about the boiling point of oxygen, —181·4°, to a white crystalline semi-transparent mass. On allowing the pressure and temperature to increase gradually by closing the stopcock which allowed the oxygen to escape, the solid ethylene became liquid at a pressure of 3·4 atmospheres, at which, as the author has shown, the temperature of the liquid oxygen would be —169°. This may therefore be taken as the melting point of solid ethylene.—*Ann. Phys. Chem.*, II., xxxvii, 337–340; *J. Chem. Soc.*, lvi., 821, Sept., 1889; *G. F. B.*, *Amer. Jour.*

HEREDITY.*

By Sir WILLIAM TURNER.

TWENTY-SIX years have passed by since the British Association for the Advancement of Science last assembled in this city. Many of the incidents of that meeting are still fresh in my memory, the more vividly, perhaps, because it was the first meeting of the association that I had attended. The weather, so important a factor in most of our functions, was dry and bright. The visitor, instead of being enshrouded in that canopy of mist and smoke which so often meets the traveler as he approaches your city, was greeted with light and sunshine. The cordial welcome and reception so freely granted by the community, and more especially the princely yet gracious hospitality exercised by the president, your eminent townsman, now Lord Armstrong, are all deeply imprinted on my memory. But, apart from these attractions, which added so much to the amenities of the occasion, the meeting was one of deep interest to all those members and associates who were engaged in biological study.

Lyell's famous book on the "Antiquity of Man" had been published shortly before. The essays on the "Origin of Species" by natural selection, by Charles Darwin and Alfred Russel Wallace, had appeared only five years earlier in the *Journal* of the Linnean Society, and in 1859 Darwin's treatise on the "Origin of Species," in which its illustrious author summarized the facts he had collected and the conclusions at which he had arrived, had been published. Although no president of the British Association had up to that time given his adhesion to the new theory, yet it was clear that men were beginning to see in many instances perhaps only dimly, how the theory of evolution by natural selection was destined to work a remarkable change, amounting almost to a revolution, in our conceptions of biological questions generally, and their applicability to the study of man.

At that time anthropology had not assumed so definite a position in the work of the association as it now possesses. Neither a department nor a section was devoted to it, and the subjects which it embraces were scattered abroad, either in the department of anatomy and physiology, in the section of geography and ethnology, in that of geology, or in that of statistics. It is true that a vigorous attempt was made about that time to give it a more independent position, but it was not until the association met in Nottingham, in 1866, that it was assigned a definite department, and at the Montreal meeting, in 1884, anthropology assumed the dignity of a section.

But although the youngest section of the association, the science of man is not the youngest of the sciences. Long before the British Association came into existence, man, in his physical, racial, geological, and psychological aspects, had been studied by hosts of able and industrious inquirers. All that the association has done in establishing a special section of anthropological science has been to bring together, as it were, into a single focus all those workers who apply themselves to the study of man in his various aspects.

As presiding over the proceedings of the section on this occasion it is a part of my duty to open its public business with an address. For me, as doubtless for many of those who have preceded me in this honorable office, one's mind has been somewhat exercised in the choice of a subject. In a branch of biological science so vast as anthropology, in which the room for selection is so ample, the difficulty of making a choice is perhaps still further increased. As a professional anatomist, whose life's work it had been to study the structure of the human body in its normal aspects, to inquire into the variations which it exhibits in different individuals, and to compare its structure with that of various forms of animal life, it at first occurred to me that an address on the physical characteristics of some of the races of men would be appropriate. But further consideration led me to think that such a subject would be too technical for a general audience, and that it might perhaps be productive of greater interest on the part of my auditors if I selected a topic which while strictly scientific in all its bearings yet appeals more distinctly to the popular mind, and is now attracting attention. Hence I have chosen the subject of heredity, by which I mean that special property through which the peculiarities of an organism are transmitted to its descendants throughout successive generations, so that the offspring, in their main features, resemble their parents.

The subject of heredity, if I may say so, is in the air at the present time. The journals and magazines, both scientific and literary, are continually discussing it, and valuable treatises on the subject are appearing at frequent intervals. But though so important a topic of existing scientific thought and speculation, it is by no means a new subject, and certain of its aspects were under discussion so far back as the time of Aristotle. The prominence which it has assumed of late years is in connection with its bearing on the Darwinian theory of natural selection, and, consequently, biologists generally have had their attention directed to it. But in its relations to man, his structure, functions, and diseases, it has long occupied a prominent position in the minds of anatomists, physiologists, and physicians. That certain diseases, for example, are hereditary was recognized by Hippocrates, who stated generally that hereditary diseases are difficult to remove, and the influence which the hereditary transmission of disease exercises upon the duration of life is the subject of a chapter in numerous works on practical medicine, and forms an important element in the valuation of lives for life insurance.

The first aspect of the question which has to be determined is whether any physical basis can be found for heredity. Is there any evidence that the two parents contribute each a portion of its substance to the production of the offspring, so that a physical continuity is established between successive generations? The careful study, especially during the last few years, of the development of a number of species of animals mostly, but not exclusively, among the invertebrata, by various observers, of whom I may especially name Butschli, Fol, E. Van Beneden, and Hertwig, has established the important fact that the young animal arises by the fusion within the egg or germ cell of an extremely minute particle derived from the male parent with an almost equally minute particle derived from the germ cell produced by the female parent. These particles are technically termed in the former case the *male pronucleus*, in the latter the *female pronucleus*, and the body formed by their fusion is called the *segmentation nucleus*. These nuclei are so small that it seems almost a contradiction in terms to speak of their magnitude; rather one might say their minimitude, for it requires the higher powers of the best microscopes to see them and follow out the process of conjugation. But notwithstanding their extreme minuteness, the pronuclei and the segmentation nucleus are complex both in chemical and molecular structure. From the segmentation nucleus produced by the fusion of the pronuclei with each other, and from corresponding changes which occur in the protoplasm of the egg which surrounds it, other cells arise by a process of division, and these in their turn also multiply by division. These cells arrange themselves in course of time into layers which are termed the germinal or embryonic layers. From these layers arise all the tissues and organs of the body, both in its embryonic and adult stages of life. The starting point of each individual organism—*i. e.*, of each new generation—is therefore the segmentation nucleus. Every cell in the adult body is derived by descent from that nucleus through repeated division. As the segmentation nucleus is formed by the fusion of material derived from both parents, a physical continuity is established between parents and offspring. But this physical continuity carries with it certain properties which cause the offspring to reproduce, not only the bodily configuration of the parent, but other characters. In the case of man we find, along with the family likeness in form and features, a correspondence in temperament and disposition, in the habits and mode of life, and sometimes in the tendency to particular diseases. This transmission of characters from parent to offspring is summarized in the well known expression that "like begets like," and it rests upon a physical basis.

The size of the particles which are derived from the parents, called the male and female pronuclei, the potentiality of which is so utterly out of proportion to their bulk, is almost inconceivably small when compared with the magnitude of the adult body. Further, by the continual process of division of the cells, the substance of the segmentation nucleus is diffused throughout the body of the new individual produced through its influence, so that each cell contains but an infinitesimal particle of it. The parental dilution, if I may so say, is so attenuated as to surpass the imagination of even the most credulous believer in the attenuation of drugs by dilution. And yet these particles are sufficient to stamp the characters of the parents, of the grandparents, and of still more remote ancestors on the offspring, and to preserve them throughout life, notwithstanding the constant changes to which the cells forming the tissues and organs of the body are subjected in connection with their use and nutrition. So marvelous, indeed, is the whole process, that even the exact contributions to recent knowledge on the fusion of the two pronuclei, instead of diminishing our wonder, have intensified the force of the expression "*magnum hereditatis mysterium.*"

In considering the question of how new individuals are produced, one must keep in mind that it is not every cell in the body which can act as a center of reproduction for a new generation, but that certain cells, which we name germ cells and sperm cells, are set aside for that purpose. These cells, destined for the production of the next generation, form but a small proportion of the body of the animal in which they are situated. They are as a rule marked off from the rest of the cells of its body at an early period of development. The exact stage at which they become specially differentiated for reproductive purposes varies, however, in different organisms. In some organisms, as is said by Balbiani to be the case in *Chironomus*, they apparently become isolated before the formation of the germinal layers is completed; but, as a rule, their appearance is later, and in the higher organisms not until the development of the body is relatively much more advanced.

The germ cells after their isolation take no part in the growth of the organism in which they arise, and their chief association with the other cells of its body is that certain of the latter are of service in their nutrition.

The problem, therefore, for consideration is the mode in which these germ or reproductive cells become influenced, so that after being isolated from the cells which make up the bulk of the body of the parent they can transmit to the offspring the characters of the parent organism. Various speculations and theories have been advanced by way of explanation. The well known theory of pangenesis, which Charles Darwin with characteristic moderation put forward as merely a provisional hypothesis, assumes that *gemmules* are thrown off from each different cell or unit throughout the body which retain the characters of the cells from which they spring; that the gemmules aggregate themselves either to form or to become included within the reproductive cells; and that in this manner they and the characters which they convey are capable of being transmitted in a dormant state to successive generations, and to reproduce in them the likeness of their parents, grandparents, and still older ancestors.

In 1872, and four years afterward, in 1876, Mr. Francis Galton published most suggestive papers on kinship and heredity (*Proc. Roy. Soc.*, Lond., 1872, and *Journ. Anthrop. Inst.*, vol. v., 1876). In the latter of the papers he developed the idea that "the sum total of the germs, gemmules, or whatever they may be called," which are to be found in the newly fertilized ovum, constitute a *stirp*, or root; that the germs which make up the stirp consist of two groups—the one which develops into bodily structure of the individual, and which constitutes, therefore, the personal structure; the other, which remains latent in the individual, and forms, as it were, an undeveloped residuum; that it is from these latent or residual germs that the sexual elements intended for producing the next generation are derived, and that these germs exercise a predominance in matters of heredity; further, that the cells which make up the personal structure of the body of the individual exercise only in a very faint degree any influence on the reproductive cells, so that any modifications acquired by the individual are barely, if at all, inherited by the offspring.

Subsequent to the publication of Mr. Galton's essays, valuable contributions to the subject of heredity have been made by Profs. Brooks, Jaeger, Naegeli, Nussbaum, Weismann, and others.

Prof. Weismann's theory of heredity embodies the same fundamental idea as that propounded by Mr. Galton; but as he has employed in its elucidation a phraseology which is more in harmony with that generally used by biologists, it has had more immediate attention given to it.

As Weismann's essays have, during the present year, been translated for and published by the Clarendon Press (Oxford, 1889), under the editorial superintendence of Messrs. Poulton, Schonland, and Shipley, they are now readily accessible to all English readers.

Weismann asks the fundamental question, "How is it that a single cell of the body can contain within itself all the hereditary tendencies of the whole organism?"

He at once discards the theory of pangenesis, and states that in his belief the germ cell, so far as its essential and characteristic substance is concerned, is not derived at all from the body of the individual in which it is produced, but directly from the parent germ cell from which the individual has also arisen.

He calls his theory the *continuity of the germ plasm*, and he bases it upon the supposition that in each individual a portion of the specific germ plasm derived from the germ cell of the parent is not used up in the construction of the body of that individual, but is reserved unchanged for the formation of the germ cells of the succeeding generation.

Thus, like Mr. Galton, he recognizes that in the stirp or germ there are two classes of cells destined for entirely distinct purposes—the one for the development of the *soma* or body of the individual, which class he calls the *somatic* cells; the other for the perpetuation of the species, *i. e.*, for reproduction.

In further exposition of his theory Weismann goes on to say, as the process of fertilization is attended by a conjugation of the nuclei of the reproductive cells—the pronuclei referred to in an earlier part of this address—that the nuclear substance must be the sole bearer of hereditary tendencies. The two uniting nuclei would contain the germ plasm of the parents, and this germ plasm also would contain that of the grandparents as well as that of all previous generations.

To make these somewhat abstract propositions a little more clear, I have devised the following graphic mode of representation—

Let the capital letters A, B, C, D, etc., express a series of successive generations. Suppose A to be the starting point, and to represent the somatic or personal structure of an individual; then *a* may stand for the reproductive cells or germ plasm, from which the offspring of A, viz., B, is produced. B, like A, has both a personal structure and reproductive cells or germ plasm, the latter of which is represented by the letters *ab*, which are intended to show that, while belonging to B, they have a line of continuity with A. C stands for an individual of the third generation, in which the reproductive plasm is indicated by *abc*, to express that, though within the body of C, the germ plasm is continuous with that of both *b* and *a*. D also contains the reproductive cells, *abcd*, which are continuous with the germ plasm of the three preceding generations, and so on.

It follows, therefore, from this theory that the germ plasm possesses throughout the same complex chemical and molecular structure, and that it would pass through the same stages when the conditions of development are the same, so that the same final product would arise.

Each successive generation would have, therefore, an identical starting point, so that an identical product would arise from all of them.

Weismann does not absolutely assert that an organism cannot exercise a modifying influence upon the germ cells within it; yet he limits this influence to such slight effect as that which would arise from the nutrition and growth of the individual, and the reaction of the germ cell upon changes of nutrition caused by alteration in growth at the periphery, leading to some change in the size, number, and arrangements of its molecular units.

But he throws great doubt upon the existence of such a reaction, and he, more emphatically than Mr. Galton, argues against the idea that the cells which make up the somatic or personal structure of the individual exercise any influence on the reproductive cells.

From his point of view the structural or other properties which characterize a family, a race, or a species are derived solely from the reproductive cells through continuity of their germ plasm, and are not liable to modification by the action on them of the organs or tissues of the body of the individual organism in which they are situated.

To return for one moment to my graphic illustration in elucidation of this part of the theory. The cells which make up the personal structure of A or B would exercise no effect upon the character of the reproductive cells *a* or *ab* contained within them. These latter would not be modified or changed in their properties by the action of the individual organism, A or B. The individual, B, would be in hereditary descent, not

* Opening address by Prof. Sir William Turner, M.B., LL.D., F.R.SS.L. and E., President of Section H, Anthropology. Read before the British Association, Newcastle, 1889.—*Nature.*

from A + a, but only from a, with which its germ plasm, ab, would be continuous, and through which the properties of the family, race, or species would be transmitted to C, and so on to other successive generations.

The central idea of heredity is permanency; that like begets like, or, as Mr. Galton more fitly puts it, that "like *tends* to produce like."

But though the offspring conform with their parents in all their main characteristics, yet, as every one knows, the child is not absolutely like its parents, but possesses its own character, its own individuality. It is easy for any one to recognize that differences exist among men when he compares one individual with another; but it is equally easy for those who make a special study of animals to recognize individual differences in them also.

Thus a pigeon or canary fancier distinguishes without fail the various birds in his flock, and a shepherd knows every sheep under his charge.

But the anatomist tells us that these differences are more than superficial—that they also pervade the internal structure of the body.

In a paper which I read to the meeting of this association in Birmingham so long ago as 1865,* after relating a series of instances of variation in structure observed in the dissections of a number of human bodies, I summarized my conclusion as follows: "Hence, in the development of each individual, a morphological specialization occurs both in internal structure and external form by which distinctive characters are conferred, so that each man's structural individuality is an expression of the sum of the individual variations of all the constituent parts of his frame."

As in that paper I was discussing the subject only in its morphological relations, I limited myself to that aspect of the question; but I might with equal propriety have also extended my conclusion to other aspects of man's nature.

Intimately associated, therefore, with the conception of heredity—that is, the transmission of characters common to both parent and offspring—is that of variability—that is, the appearance in an organism of certain characters which are unlike those possessed by its parents. Heredity, therefore, may be defined as the perpetuation of the like; variability, as the production of the unlike.

And now we may ask, Is it possible to offer any feasible explanation of the mode in which variations in organic structure take their rise in the course of development of an individual organism?

Anything that one may say on this head is, of course, a matter of speculation, but certain facts may be adduced as offering a basis for the construction of an hypothesis, and on this matter Prof. Weismann makes a number of ingenious suggestions.

Prior to the conjugation of the male and female pronuclei to form the segmentation nucleus, a portion of the germ plasm is extruded from the egg to form what are called the *polar bodies*.

Various theories have been advanced to account for the significance of this curious phenomenon. Weismann explains it on the hypothesis that a reduction of the number of ancestral germ plasms in the nucleus of the egg is a necessary preparation for fertilization and for the development of the young animal. He supposes that by the expulsion of the polar bodies one-half the number of ancestral germ plasms is removed, and that the original bulk is restored by the addition of the male pronucleus to that which remains. As precisely corresponding molecules of this plasm need not be expelled from each ovum, similar ancestral plasms are not retained in each case; so that diversities would arise even in the same generation and between the offspring of the same parents.

Minute though the segmentation nucleus is, yet microscopic research has shown that it is not a homogeneous, structureless body, but is built up of different parts. Most noteworthy are the presence of extremely delicate threads of fibrils, called the *chromatin filaments*, which are either coiled on each other or intersect to form a network-like arrangement. In the meshes of this network a viscous—and, so far as we yet know, structureless—substance is situated. Before the process of division begins in the segmentation nucleus, these filaments swell up and then proceed to arrange themselves at first into one and then into two star-like figures before the actual division of the nucleus takes place.† It is obvious, therefore, that the molecules which enter into the formation of the segmentation nucleus can move within its substance, and can undergo a readjustment in size and form and position. But this readjustment of material is, without doubt, not limited to those relatively coarse particles which can be seen and examined under the microscope, but applies to the entire molecular structure of the segmentation nucleus. Now it must be remembered that cells of the embryo from which all the tissues and organs of the adult body are derived are themselves descendants of the segmentation nucleus, and they will doubtless inherit from it both the power of transmitting definite characters and a certain capacity for readjustment both of their constituent materials and the relative positions which they may assume toward each other. One might conceive, therefore, that if in a succession of organisms derived from common ancestors the molecular particles were to be of the same composition and to arrange themselves in the segmentation nucleus and in the cells derived from it on the same lines, these successive generations would be alike; but if the lines of adjustment and the molecular constitution were to vary in the different generations, then the products would not be quite the same. Variations in structure, and to some extent also in the construction of parts, would arise, and the unlike would be produced.

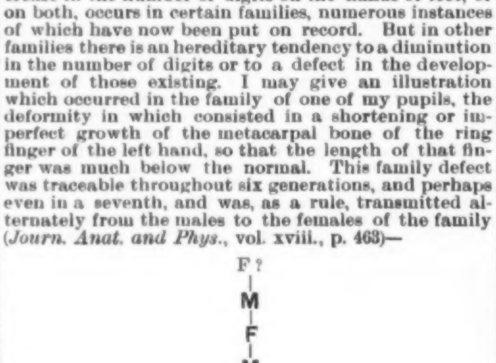
In this connection it is also to be kept in mind that in the higher organisms, and, indeed, in multicellular organisms generally, an individual is derived, not from one parent only, but from two parents. Weismann emphasizes this combination as the cause of the production of variations and the transmission of hereditary individual characters. If the proportion of the particles derived from each parent and the forces which they exercise were precisely the same in any individual case, then one could conceive that the product would be a mean of the components provided by the two parents.

But if one parent were to contribute a larger proportion than the other to the formation of a particular organism, then the balance would be disturbed, the offspring in its character would incline more to one parent than to the other, according to the proportion contributed by each, and a greater scope for the production of variations would be provided. These differences would be increased in number in the course of generations, owing to new combinations of individual characters arising in each generation.

As long as the variations which are produced in an organism are collectively within a certain limitation, they are merely individual variations, and express the range within which such an organism, though exhibiting differences from its neighbors, may yet be classed along with them in the same species. It is in this sense that I have discussed the term variability up to the present stage of this address. Thus all those varieties of mankind which, on account of differences in the color of the skin, we speak of as the white, black, yellow races and red skins are men, and they all belong to that species which the zoologists term *Homo sapiens*.

But the subject of variability cannot, in the present state of science, be confined in its discussion to the production of individual variations within the limitations of a common species. Since Charles Darwin enunciated the propositions that favorable variations would tend to be preserved and unfavorable ones to be destroyed, and that the result of this double action, by the accumulation of minute existing differences, would be the formation of new species by a process of natural selection, this subject has attained a much wider scope, has acquired increased importance, and has formed the basis of many ingenious speculations and hypotheses. As variations, when once they have arisen, may be hereditarily transmitted, the Darwinian theory might be defined as heredity modified and influenced by variability.

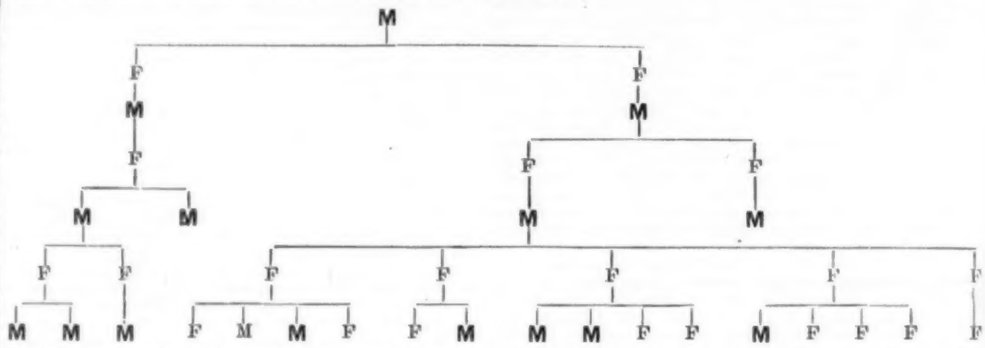
This is not the place to enter on a general discussion of the Darwinian theory, and even if it were, the time at our disposal would not admit of it. But there are some aspects of the theory which would need to be referred to in connection with the subject now before us. It may be admitted that many variations which may arise in the development of an individual, and which are of service to that individual, would tend to be preserved and perpetuated in its offspring by hereditary transmission. But it is also without question that variations which are of no service, and, indeed, are detrimental, to the individual in which they occur, are also capable of being hereditarily transmitted. This statement is amply borne out in the study of those important defects in bodily structure which pathologists group together under the name of congenital malformations. I do not require to go into much detail on this head, or to cite cases in which the congenital defect can only be exposed by dissection, but may refer, by way of illustration, to one or two examples in which the defect is visible on the surface of the body. The commonest form of malformation the hereditary transmission of which has been proved is where an increase in the number of digits on the hands or feet, or on both, occurs in certain families, numerous instances of which have now been put on record. But in other families there is an hereditary tendency to a diminution in the number of digits or to a defect in the development of those existing. I may give an illustration which occurred in the family of one of my pupils, the deformity in which consisted in a shortening or imperfect growth of the metacarpal bone of the ring finger of the left hand, so that the length of that finger was much below the normal. This family defect was traceable throughout six generations, and perhaps even in a seventh, and was, as a rule, transmitted alternately from the males to the females of the family (*Journ. Anat. and Phys.*, vol. xviii., p. 463)—



In this and the following diagrams M stands for male, F for female, while the block type (**M** or **F**) marks the individual or generation in which the variation occurred.

Another noticeable deformity which is known to be hereditary in some families, and which may be familiar to some of my auditors, is that of imperfect development of the upper lip and roof the mouth, technically known as hare lip and cleft palate.

These examples illustrate what may be called the coarser kinds of hereditary deformity, where the redundancies or defects in parts of the body are so gross as at once to attract attention. But modifications or variations in structure that can be transmitted from parent to offspring are by no means limited to changes which can be detected by the naked eye. They are sometimes so minute as to be determined rather by the modifications which they occasion in the function of the organ than by the ready recognition of structural variations. One of the most interesting of these is the affection known as Daltonism, or color blindness, which has distinctly been shown to be hereditary, and which is due, apparently, in the majority of cases, to a defect in the development of the retina, or of the nerve of sight which ends in it, though in some instances they may be occasioned by defective development of the brain itself. Dr. Horner has related a most interesting family history (cited in "Die Allgemeine Pathologie," by Dr. Edwin Klebs, Jena, 1887) in which the color blindness was traced through seven generations. In this family the males were the persons affected, though the peculiarity was transmitted through the females, who themselves remained unaffected. The family tree showed that in the sixth generation seven mothers had children. Their sons, collectively nine in number, were all color blind with the exception of one son, while none of their nine daughters showed the hereditary defect. (See diagram below.)



The eye is not the only organ of sense which exhibits a tendency to the production of hereditary congenital defects. The ear is similarly affected, and intimately associated with congenital deafness is an inability to speak articulately, which occasions the condition termed deaf-mutism. Statisticians have given some attention to this subject, both as regards its relative frequency and its hereditary character. The writer of the article "Vital Statistics," in the report of the Irish census commissioners during the decades ending 1851, 1861, 1871, has discussed at some length the subject of congenital deaf-mutism, and has produced a mass of evidence which proves that it is often hereditarily transmitted. In the Census Report for 1871 (vol. lxxii., Part II., "Report on the Status of Disease," p. 1, 1873), 3,297 persons were returned as belonging to this class, and in 393 cases the previous or collateral branches of the family were also mute. In 211 of these the condition was transmitted through the father; in 182 through the mother. In 2,579 cases there was one deaf-mute in a family; in 379 instances, two; in 191 families, three; in 53, four; in 21, five; in 5, six; and in each of two families no fewer than seven deaf mutes were born of the same parents. In one of these two families neither hereditary predisposition nor any other probable physiological or pathological reason was assigned to account for the peculiarity, but in the other family the parents were first cousins. Mr. David Buxton, who has paid great attention to this subject (*Liverpool Medico-Chirurg. Journ.*, July, 1857; January, 1859), states that the probability of congenital deafness in the offspring is nearly seven times greater when both parents are deaf than when only one is so; in the latter case the chance of a child being born deaf is less than three-quarters per cent.; in the former the chances are that five per cent. of the children will be deaf mutes. Mr. Buxton refers to several families where the deaf-mutism has been transmitted through three successive generations, though in some instances the affection passes over one generation to reappear in the next. He also relates a case of a family of sixteen persons, eight of whom were born deaf and dumb, and one at least of the members of which transmitted the affection to his descendants as far as the third generation. There can be little doubt that congenital deaf-mutism, in the great majority of instances, is associated with a defective development, and, therefore, a structural variation, of the organ of hearing, though in some cases, perhaps, the defect may be in the development of the brain itself.

Although a sufficient number of cases has now been put on record to prove that in some families one or other kind of congenital deformity may be hereditarily transmitted, yet I do not wish it to be supposed that congenital malformations may not arise in individuals in whom no hereditary tendency can be traced. It is undoubtedly true that family histories are in many cases very defective, and frequently cannot be followed back for more than one, or, at the most, two generations; so that it is not likely that an hereditary predisposition may exist in many instances where it cannot be proved. Still, allowing even for a considerable proportion of such cases, a sufficient number will remain to warrant the statement that malformations or variations in structure which have not been displayed by their ancestors may arise in individuals belonging to a particular generation.

(*To be continued.*)

HOW TO REMOVE WARTS AND TATTOO MARKS.

I find the following suggestive derelict wandering about the ocean of journalism, writes Mark Twain in the New York *Sun:*

"I'd give one thousand dollars," said a well-to-do New Yorker the other day, "to have that mark removed," and he held out a well-shaped and well-cared-for hand, on the back of which, between the thumb and first finger, was tattooed a big blue anchor. "When I was a little fool at school, with my head full of stories of adventure, my highest ambition was to go to sea. An old sailor who lived in the village tattooed about a dozen of us on the sly, and I remember the lies I told

* Transactions of Sections, p. 111, 1865, and Trans. Roy. Soc. Edinburgh, vol. xxiv., 1865.

† The observations more especially of Flemming, E. Van Beneden, Strasburger, and Carnoy may be referred to in connection with the changes which take place in nuclei prior to and in connection with their division.

my mother, as I kept my hand done up in a rag, pretending I had cut it, till the sore healed. Then she gave me such a thrashing as broke up my plan, fortunately, to have a fine red and blue heart done on the back of the other. The disfigurement has caused me no end of annoyance since, and has cost me considerable money for gloves, which I always wear, winter and summer, though I detest them in warm weather. But a man can't wear gloves at the table, and often at restaurants I catch people staring at my hand and I wonder if they think I have served my term in the fo'castle of some oyster scow or lumber schooner."

A tattooed mark is easily removed. May I drop into personal history? When I was a small boy I had my share of warts. I tried in turn the 368 ways of removing them, but without results; indeed, I seemed to get wartier and wartier right along. But at last somebody revealed to me the 369th way, and I tried it. Thus: I drove a needle down into the basement of the wart; then held the other end of the needle in the flame of a candle some little time; the needle became red hot throughout its length, and proceeded to cook the wart. Presently I drew the needle out; if it had white atoms like nits sticking about its point, that wart was done; if the point was clear, I drove it in again and cooked till I got those white things. They were the roots of the wart. Twenty-four hours later the wart would become soft and flabby, and I removed it with a single wipe of my hand. Where it had been was a smooth surface now, which quickly healed and left no scar. Within two days I was wartless, and have so remained until this day.

Well, a long time afterward, when I was sixteen years old, a sailor tattooed an anchor and rope on the back of my left hand with India ink. The color was a deep, dark blue and extravagantly conspicuous. I was proud of it for awhile, but by the time I had worn it nine years I was tired of it and ashamed of it. I could find nobody who could tell me how to get rid of it; but at last my wart experience of near half a generation before occurred to me, and I got my several needles and a candle straightway. I drove the needles along just under the surface of the skin and tolerably close together, and made them include the whole tattoo mark, then I fired upon them and cooked that device thorough. Next day I wiped the device off with my hand. The place quickly healed and left no scar. A faint bluish tinge remained, and I was minded to begin again and cook that out; but as it was hardly detectable and not noticeable, it did not seem worth the fuel, and so I left it there, and there it is yet, though I suppose I am the only member of my tribe that knows it.

I was in London a good many years ago when the Tichborne claimant's case was being tried, and a batch of learned experts testified that an India ink tattoo mark could not be removed, but I was not asked to testify, and so those people don't know any better to this day. Let the "well-to-do New Yorker" fetch me some needles and a candle and name his bet. I will take him up.

THE USE OF DISINFECTANTS AT JOHNSTOWN.

By GEO. G. GROFF, M.D., Member of the State Board of Health.

WHEN, on June 1, 1889, representatives of the State Board of Health of Pennsylvania reached the desolated Conemaugh Valley, to do what could be done to prevent the occurrence and spread of disease among the exhausted and stricken survivors, the best estimates that could hastily be secured showed that 10,000 human beings, 1,000 horses, 1,000 cows, together with a great number of hogs, dogs, chickens, cats, etc., were drowned and buried in the debris at Johnstown and in the drift piles down the river, while 10,000 sufferers were without shelter, wet, hungry, and distracted. There was slime, mud, carcasses of domestic animals, human bodies, everywhere.

"No pen has yet fully described the condition that existed the next day after the waters from South Fork Lake had swept the valley. The pen never will picture the desolation that existed or tell of the difficulties that confronted the inhabitants of the stricken valley. The homes that were not swept away were left in the most unsanitary condition imaginable. The flood in many localities reached a height of thirty to ninety feet. This water contained or was heavily charged with debris and every kind of filth, and whatever this water touched it contaminated. As a result every house in the flooded district was filled to the second floor in most cases with most offensive matter. In many cases dead animals were found in parlors and scores of dead horses were removed from dwellings and business stands. Everything was covered with mud. There was not a place where the flood touched that man could lay his head with safety." If there ever was a place where disinfectants ought to prove of value, it was here.

THE DISINFECTANTS USED.

The first used was *fire*. On the evening of June 1, telegrams were sent to all the sheriffs of counties bordering the river below Johnstown, to tear open the drift piles, recover the human bodies, and to burn all bodies of domestic animals. Later, gangs of men were dispatched up and down the river from Pittsburg in steamboats, and, where boats could not ascend, on foot, for this purpose. For fully three weeks immense fires were burning at Johnstown, formed of the debris, and in these hundreds of animals were cremated.

While the animals which could be easily reached were being burned, it was learned that supplies of copperas could be obtained at the Johnstown Chemical Works, and at once small supplies began to be hauled down to the town, but for a considerable time the communication was so bad that the supplies were deficient. This copperas was pounded up fine, and sometimes sprinkled over the spot to be disinfected, at other times dissolved in water and so used.

Just so soon as the railroads were fairly opened, and supplies began to come in, large gifts of disinfectants were received from all the principal manufacturers of the same in the United States, and one gift, valued at $2,500, came from England (Quibble's disinfectant). North Carolina sent about 400 barrels of pine tar and resin. The United States government donated large supplies of corrosive sublimate and copperas. It may aid to illustrate the confusion attending the work during the early days after the disaster, that while the Board of Health employed one clerk whose sole duty was to hunt up articles consigned to the board, one gift of bromo-chloralum was not discovered until about September 20, but it had been consigned to Surgeon-General Hamilton.

The following list, though not complete, will give some idea of the amount of disinfectants used by the board:

4,000	barrels quicklime.
500	" chloride of lime.
1,700	four-pound bottles bromide.
110	barrels Bullens'.
100	tons copperas.
1,000	gallons carbolic acid.
3	carboys muriatic acid.
40	gallons nitric acid.
180	barrels resin.
200	" pine tar.
73	" pitch.
5	" liquid phenile.
15	" sanitas.
3	" phenique.
100	kegs utopia.
10	carboys embalming fluid.
720	bottles sodium hypochlorides.
700	" Platt's chlorides.
116	pounds corrosive sublimate.
100	Werther's disinfectants.
50	bottles P. R.R. disinfectants.
100	" purity.
5	packages sanitaline.
100	bottles bromo-chloralum.
1	cargo of Quibble's disinfectants, valued at $2,500, and donated by Quibble Brothers, England.

On one day about $10,000 worth of disinfectants were ordered by the board. These, piled up in an open warehouse, near the principal commissary, had a most excellent moral effect, for the people felt that the Board of Health had the sinews of war with which to combat disease at its first appearance.

HOW DISTRIBUTED.

Just so soon as the streets were opened and bridges built, so that communication was possible between the *twenty* devastated villages and boroughs which comprised the devastated district, some twelve depots were established at the most convenient points. These were stocked with disinfectants, and each placed in charge of a competent person. Large placards were printed and posted all over the devastated region, telling the people where they could obtain disinfectants *free*. Circulars of information were printed and placed in every house, and posted all over the region, explaining in the plainest language what the people ought to do to preserve health in the emergency, and how to properly use the disinfectants. The result was that the people came by the hundred and carried the disinfectants to their homes and used them with good effect. These supply stations were kept open just so long as the places were in a bad sanitary condition, and are now believed to have accomplished much good.

HOW USED.

For the large gangs of workmen and for the homeless inhabitants, the Board of Health found it necessary to erect about 125 privies. These were daily disinfected under a careful foreman. All places where filth was thrown about the camps of the laborers and of the soldiers were also daily disinfected. The bromine, chloride of lime, carbolic acid, Quibble's and other disinfectants were dissolved in water, and then, by means of sprinkling cans, the yards and all the premises of hundreds of persons were disinfected so far as this was possible. So soon as the streets were cleared of the *debris* two sprinkling carts were set to running, and these used solutions of disinfectants, which had a good effect upon the general atmosphere. Lime was furnished free in such quantities that all who would could use it inside and outside about their premises. Gangs of men were kept about where the laborers were at work clearing up, and whenever a place became very offensive, disinfectants were freely used. This did great good, for, in the early days of the disaster, when nearly every one expected pestilence, the laborers were especially suspicious of every foul odor, and the presence of a disinfectant had a very reassuring effect. Disinfectants were freely used about the morgues and in every place where it could be hoped that they would do good.

THE RESULT.

From first to last, there has been a remarkably small amount of sickness in the whole devastated region. Where it was reasonable to suppose that hundreds would perish, there has been scarcely any sickness at all, not much more at least than what would have ordinarily occurred, and one factor in producing this result was the liberal use of disinfectants.

ADVICE RECEIVED IN REFERENCE TO DISINFECTANTS.

Quite a number of letters were received offering to sell formulæ for disinfectants, or to manufacture them on the ground at a nominal price. When it had been raining nearly every day for two weeks and the mud was about knee deep, a letter was received, reminding the board that dry earth was a good disinfectant. Another recommended to "*fill the whole valley with chlorine gas*," as the surest way to purify it. An old physician held that fire was the only sure disinfectant, "and even wet articles soaked with petroleum and a match applied, become harmless." Another recommended salt and potassium permanganate. The editor of a metropolitan paper wrote and gave in full the formula used by certain robbers, who during a plague at Marseilles, France, robbed the dead without fear of contracting the pestilence. This was not tried, since no pestilence arose to test its efficacy.

DANGEROUS DISINFECTANTS.

A few forms came before the board in what were deemed dangerous forms. One was in the shape and general appearance of chocolate cakes, and very liable to be eaten by children. There were several powders containing corrosive sublimate, and no odor being present, these too were deemed dangerous for general use, but did good service in the great emergency.

LACTIC ACID A CAUSE OF RHEUMATIC DISEASE.

By Dr. B. W. RICHARDSON.

WE know lactic acid as the result of a particular fermentation, which we can produce artificially out of the same substances as those we use after the manner of foods; and we know that it is generated freely, we may say profusely, in the human body so soon as the fever which heralds in an acute rheumatic seizure is well marked. These facts alone lead to the fair inference that under the rheumatic zymosis a product of zymosis has been developed, one that is foreign to the natural zymosis, and one that but for its free elimination might be a source of disease as a toxic substance. But after all the presence of the acid might be a mere coincidence. Lactic acid might be simply an excrete, and of itself negative and harmless. An inquiry therefore was called for, whether this acid has any peculiar toxic properties, and if it has, whether the symptoms it calls forth bear resemblance to the secondary symptoms which signalize the acute rheumatic condition during which it is developed in the body.

To the elucidation of this question, the action of lactic acid on healthy living bodies, I devoted many months of research in the years 1855–58. The results were decisive. They showed, beyond dispute, that the special characters of rheumatic disease, minus the acute preliminary fever, could be induced in the fullest degree by simply charging the tissues of a living animal, susceptible to rheumatic disease, with the acid. They showed that the passive serous and fibrous structures were the structures primarily affected, and they proved that the various pathological changes incident to acute rheumatic heart disease admitted of being traced through all their stages, from the acute into the chronic or permanent conditions of disease.

There are other products of an acid kind which result from other modifications of fermentation. Could these products produce any specific symptoms on being introduced into the living bodies of susceptible animals?

Research was made with one of these, namely, *formic acid*, the acid of the methylic series of the alcoholic group; and as before, the results were affirmative, the symptoms being distinctively those of diseased conditions well known in practice, although different in character from the symptoms caused by the lactic acid.

Research was carried out with another acid derived from fermentation, namely, *butyric acid*, and a distinct set of symptoms most characteristic of some of the best known diseases were also synthetically induced.

There are alkaline products resulting from putrefactive fermentation. Could these, by their presence, lead to specific symptoms resembling those which signalize any of the diseases of the human species? The action of certain of the alkaline products was tested, and the results were again affirmative, in the most striking degree.

Once more. In some fermentations there follow other products, which are neither acid nor alkaline, but which partake rather of the nature of alcohols or of ethers. Was it possible that certain of these were capable of inducing symptoms resembling the symptoms of common recognizable diseases of the human family? The question was asked by experiment, and the answer was as fully pronounced in the affirmative as in any of the other examples of the research. Among the substances tested in this way were *amylene*, *mercaptan* or *sulphur alcohol*, *sulphide of ethyl*, the *hydrides*, and others of a similar order.

Again, some *saline* substances indirectly connected with the natural process of vital zymosis were tested, such as soda formate, urea, the ethylates of sodium and potassium, the amylates of sodium and potassium, the different sugars, and certain alkaloids; and the details of these researches indicated that the effects observed were simple evidences of what would occur in the human subject under a modified zymosis plus secondary products like to them and due to a modified zymosis.

ACTION OF LACTIC ACID.

The results of the research with lactic acid were the first observed, and the most striking evidence was supplied to sustain the inference that in all animals susceptible to rheumatic disease, lactic acid has the power, when existing in such an animal body in excess, of producing a class of symptoms attaching themselves mainly to the fibro-serous textures, and which, regarded in all points of view, are essentially the symptoms of acute rheumatic inflammation.

The symptoms also were obviously dependent on the presence of the poison, since by giving time for the elimination of the poison, they entirely disappeared, and on the resupplying of the poison they quickly returned. The alternation was as marked as night and day, and was as clearly in the order of natural sequence. There was also what the old schoolmen would call "metastasis" of symptoms; now one joint was affected, then another, again the heart.

It was observed that, in the experiments with lactic acid, the right as well as the left side of the heart was affected. This was to be expected; for as the poison, ready made, was injected, usually by an intra-peritoneal injection, into the body, it was taken up at once by the absorbing vessels, and carried into the right heart by the venous current, and afterward by the pulmonary circuit into the left heart, and so to the body at large through the arterial currents. The poison, therefore, of necessity, passed through both cavities of the heart, and both were affected. But if, by experiment, instead of injecting the acid directly into the venous current, there could be injected into that current an agent which, in the pulmonic circuit, should be transformed during the process of oxidation into lactic acid, then the inference is fair that the left side of the heart would alone be affected.

In rheumatic endocarditis, occurring from the formation of the poison in the body itself, the left side only is affected as a general rule. Hence I inferred that the chemical change whereby the *materies morbi* of acute rheumatism is produced is completed in the pulmonic circuit; that in the respiratory act the *acid* quality of the poison is produced; that, thus formed,

the poison is carried by the arterial circulation to be disposed of by decomposition or elimination, or both; and that it does not return as an acid by the veins, but simply a product which admits of retransformation, in the pulmonic circuit, into the acid state.

If this view be true, it is easy to connect the origin of the rheumatic disease with the digestive system, or with the arrest of special secretions. In either case, the basis of the poison may be generated and carried into the returning venous current, thence into the pulmonic circuit, and finally, after oxidation, into the left heart and through the arterial system.

This, in so far as inference—itself incidental to experiment—is allowable, is the only explanation of the peculiar fact that in rheumatism the left side of the heart usually suffers alone, and always most severely.

Regarding the origin of lactic acid in rheumatism, a view was advanced by the late Dr. Headland, to the effect that, ordinarily, the starch of the food is first converted into lactic acid, which afterward is decomposed into carbonic acid and water, and so is excreted by the lungs; but that under conditions unfavorable to this series of changes, the lactic acid accumulates. This view offers a good explanation of the argument now on hand; for on this hypothesis the starting point of the acid poison is the pulmonic circuit.

The considerations here introduced lead, moreover, to two other deductions. The first is that it is vain to look for the *materies morbi* of ordinary rheumatism in venous blood, but that it may be looked for with possible success in arterial blood. The second is that the action of the poison in ordinary rheumatism is local, *i. e.*, by its direct action on the fibro-serous surface; for if the poison were conveyed by the blood to the membrane *a posteriori*, *i. e.*, through the coronary circulation, in the case of the heart, both sides of the heart should suffer alike, which is contrary to observed fact.

Returning to the experimental facts, and leaving the argument from inference altogether for matters of fact, there are certain truths, pathological and practical, which deserve consideration.

From the circumstance that the animals on whose bodies the action of lactic acid was observed were inspected after death, at certain different and well marked phases of the disease, an opportunity was afforded of seeing for the first time the course of some pathological changes, and especially of endocarditis through each successive stage. From these observations it was found that endocarditis has three well marked periods of progression.

The primary stage is one of congestion and œdema. In this stage, the endocardial surface is intensely vascular, approaching in color to bright vermilion. The membrane has also a soft, fleecy character, giving to it a velvety appearance. The curtains of the valves are in a swollen and vascular state, which Dr. Halford very appropriately called an "œdematous condition." If the swollen valve were pricked with a needle, a clear lymph oozed from the puncture, and the valve collapsed. Occasionally during this stage, if the congestion and œdema were very great, there was a transudation of this lymph through the membrane on to its free or ventricular surface. When this occurred, there was laid the basis of a fibrinous deposit from the blood. And in one case this occurrence was strikingly marked, a positive result which is of very great value. For as in the process here described a basis for a fibrinous deposit was laid, so there was also a basis for an organized product, the connection between the deposited matter on and the matter effused beneath the membrane being direct.

While these changes were progressing in the curtains of the valves, around their margins small beads were abundantly developed. These primarily were œdematous points also: they yielded, when pricked or compressed, a clear coagulable lymph, and shrank, at once, afterward.

The general symptoms which marked this stage of artificial endocardial rheumatism were characteristic. There was a distaste for food, shivering, and feverish excitement, thirst, heat of skin, quick and short inspirations, and rapid sharp pulse. In this first stage, the heart's action was irritable; the first sound became muffled and eventually was lost altogether. This condition marked the time at which the valves were in the swollen or œdematous state. During this stage also, the second sound was sharp and accented; and, considering that in all the cases where I could trace out the signs to their pathological origin the aortic valves were red and slightly thickened, the accentuation was well accounted for. Lastly, this stage was marked by a short irritable cough, which was not dependent on mischief in the lungs, but was connected with the condition of the heart.

In the second stage of the induced disease, the pathology was modified. The endocardial surface lost its intense vascularity, but presented points at which the tendinous cords were bound down to it by loose adhesions. The intense redness shaded down to a pale pink, the membrane, superficially, being of the pink color, while beneath it there was a pale film which shaded through it. The curtains of the valves remained thickened, but less red. Their surface externally was pink above, while beneath the membrane there was a pale fleecy appearance, evidently from the presence of clear and semi-solid lymphlike exudation. With a small magnifying power, this was brought out very clearly. Sometimes the thickened valve was firmly bound down to the heart-wall by firm exudative bands. In this stage also the beads around the margin of the valves assumed the same characters and appearances as the curtains of the valves themselves; they were firmer, and pink on their external surface, with a curtain of pale exuded lymph as the background.

The symptoms of this stage were equally characteristic. The heart sounds were modified. The ventricular valves having lost their spongy or œdematous state for one in which their structure was firmer, a sound resulted from their attempts at closure, but this sound had become a murmur, which varied in intensity. At first it was wavering, dull, and obscure; then soft, and almost musical; next, loud, harsh, and prolonged. Ultimately, if recovery were permitted, it gradually subsided with the same series of modifications which introduced it, but in reversed order. The general symptoms were peculiar. The acute febrile condition passed away, and there was an obvious elimination of the poison from the body. The amount of urine passed was far above the normal quantity, and this secretion was strongly acid. The bowels were freely purged, and the alvine secretion was strongly acid. The exhalations emitted from the body of the animal were also, as in acute rheumatic disease in man, sour to the smell.

The pathology of the third stage, or that of resolution, was simple. The vascular character of the membrane, externally, was removed entirely. The exuded product beneath became firmer, and both curtains of valves and beads assumed, for a time, considerable firmness and pearly whiteness. Later, these parts softened down, as if from absorption of the exuded matter. The curtains of the valves recovered their normal characters first; the beads remained longer, and often gave rise to a loud musical systolic bruit, which conveyed the idea of a much more serious amount of valvular disease than was really presented on inspection. In this stage the general symptoms of the disease quickly disappeared.

Such is the sum of the observations I made on the influence of lactic acid on animal bodies; and reviewing the whole after a lapse of many years, the inference is as clear to me as it ever was, that the secondary action of lactic acid as a cause of rheumatic disease is proved.—*The Asclepiad.*

A CAST steel gun, weighing 235 tons, has just been shipped by Messrs. Krupp from Hamburg, for Cronstadt. The caliber of the gun is 13¼ in., and the barrel is 40 ft. in length, its greatest diameter being 6½ ft. The range of the gun is over 11 miles, and it will fire two shots per minute, each shot costing between £250 and £300. At the trials of the gun, held at Meppen, in the presence of Russian officers, the projectile, 4 ft. long, and weighing 1,800 lb., and propelled by a charge of 700 lb. of powder, penetrated 19½ in., and went 1,312 yards beyond the target. The gun, which is the largest in existence, and the heaviest yet exported by Messrs. Krupp, had to be carried from Essen to Hamburg on a car specially constructed for the purpose.

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